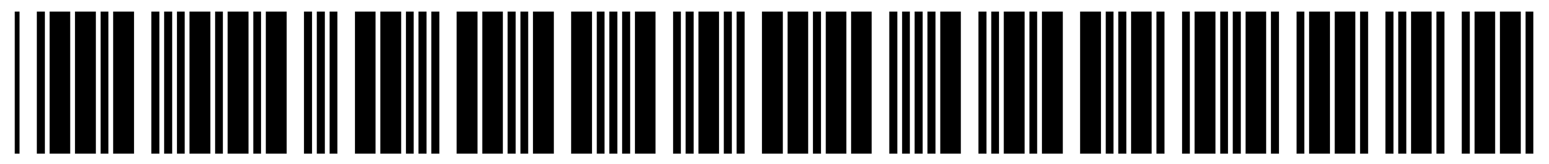

US006203268B1

(12) **United States Patent**
Miyashita

(10) **Patent No.: US 6,203,268 B1**
(45) **Date of Patent: *Mar. 20, 2001**

(54) **POSITIONING APPARATUS FOR SUBSTRATES TO BE PROCESSED**

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(73) Assignee: **Tokyo Electron Limited**, Tokyo-To (JP)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/389,069**

(22) Filed: **Sep. 2, 1999**

Related U.S. Application Data

(62) Division of application No. 08/847,721, filed on Apr. 22, 1997.

(30) **Foreign Application Priority Data**

Apr. 24, 1996 (JP) 8-127774
May 13, 1996 (JP) 8-142274

(51) **Int. Cl.**^{7} **B65G 47/24**
(52) **U.S. Cl.** **414/757**; 414/936; 414/938; 414/941
(58) **Field of Search** 414/757, 936, 414/938, 941, 738

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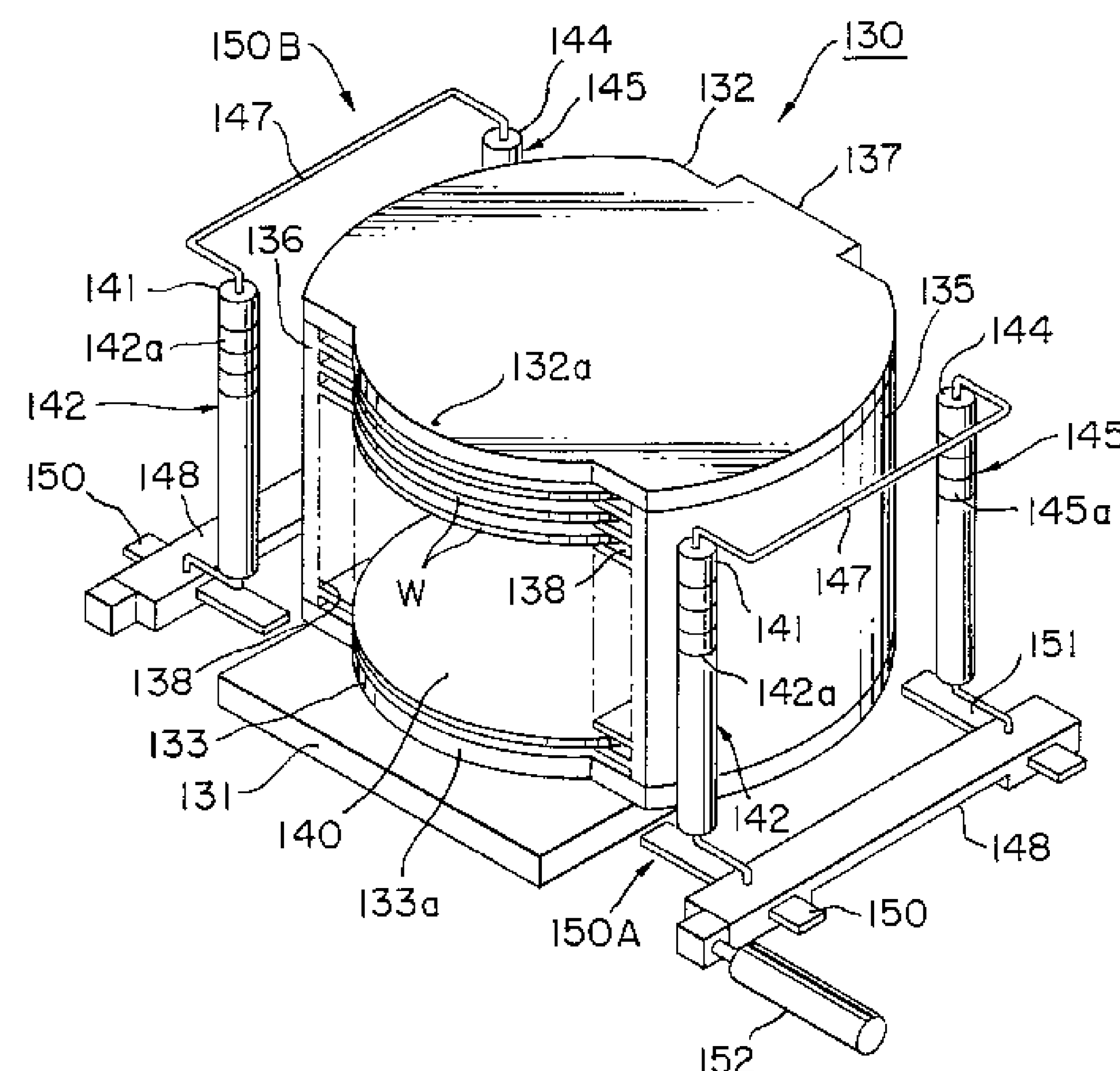
Primary Examiner—Douglas Hess
(74) *Attorney, Agent, or Firm*—Smith, Gambrell & Russell, LLP

(57) **ABSTRACT**

An apparatus is provided with a plurality of stages of mounting bases on each of which is disposed upwardly orientated, narrow tapered pins around the periphery of a semiconductor wafer, and a plurality of stages of turntables, one for each of the mounting bases, with the mounting bases being capable of moving independently of the turntables. When a wafer is transferred from a transporter arm to the tapered pins, the peripheral edge of the wafer comes into contact with the inner peripheral surfaces of the tapered pins and the wafer is centered thereby. The turntable then picks up the wafer and aligns the orientation thereof. This makes it possible to position the centers of a plurality of wafers and position the orientations thereof in a simple manner.

5 Claims, 15 Drawing Sheets



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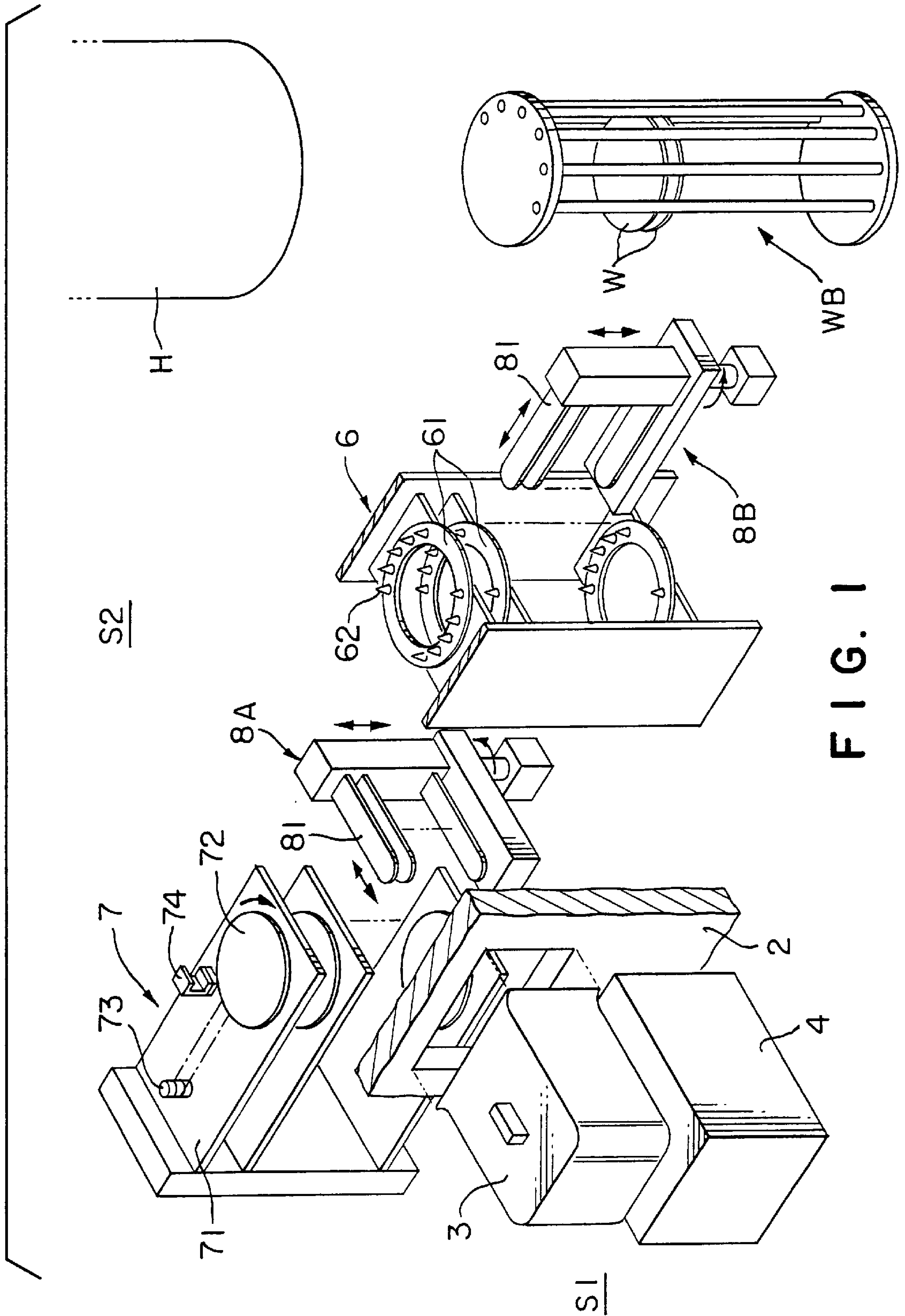
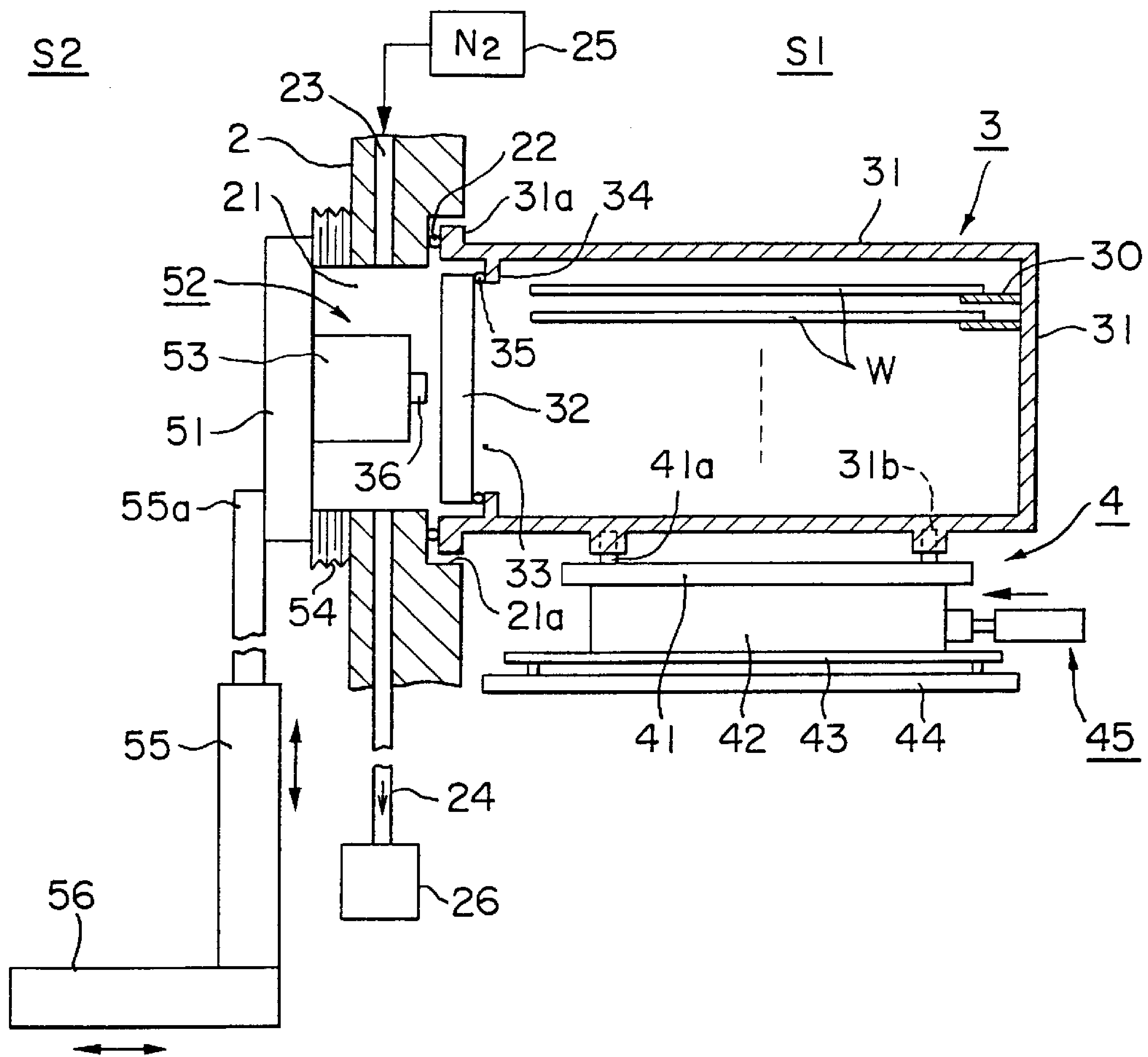


FIG. 1



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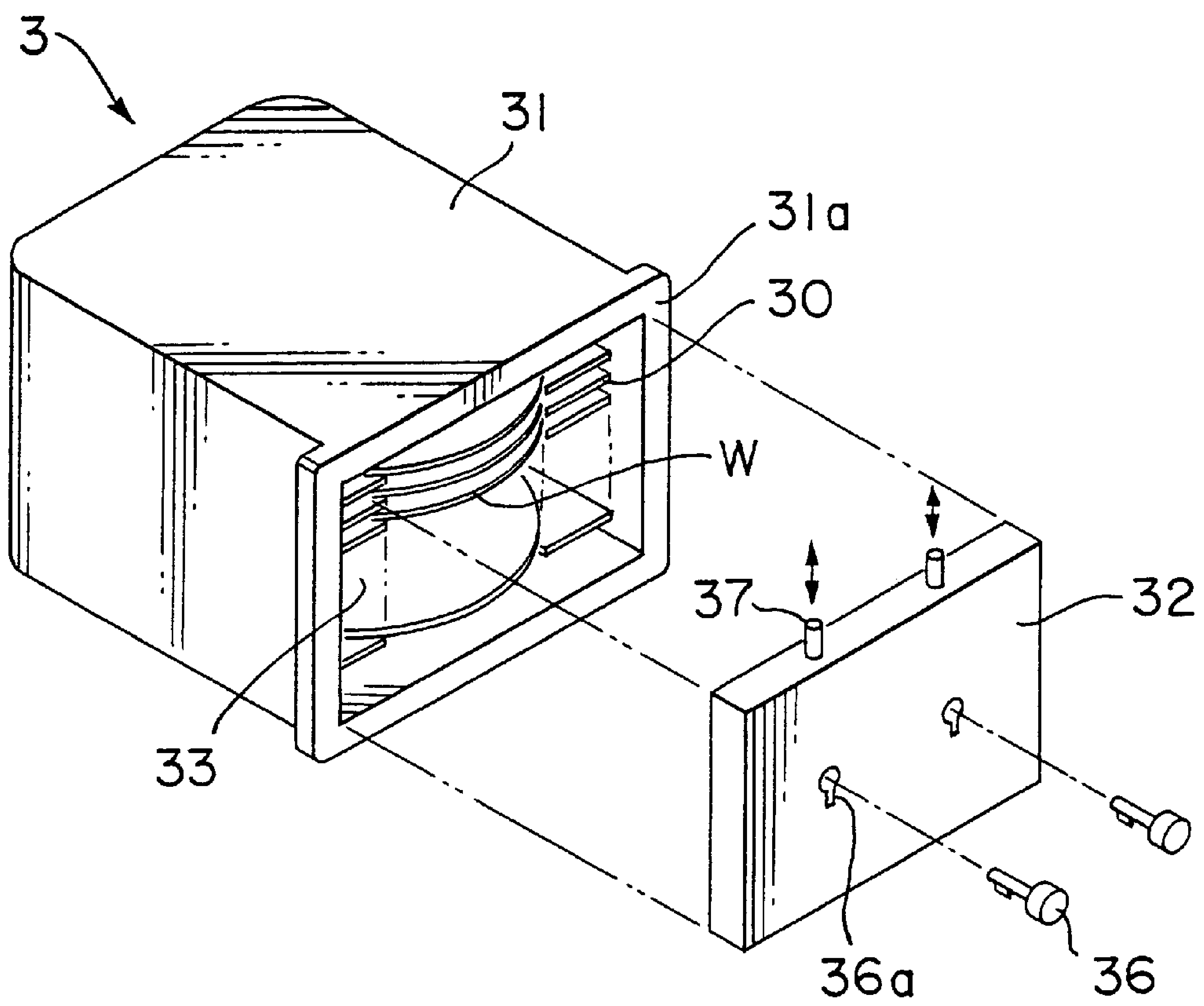

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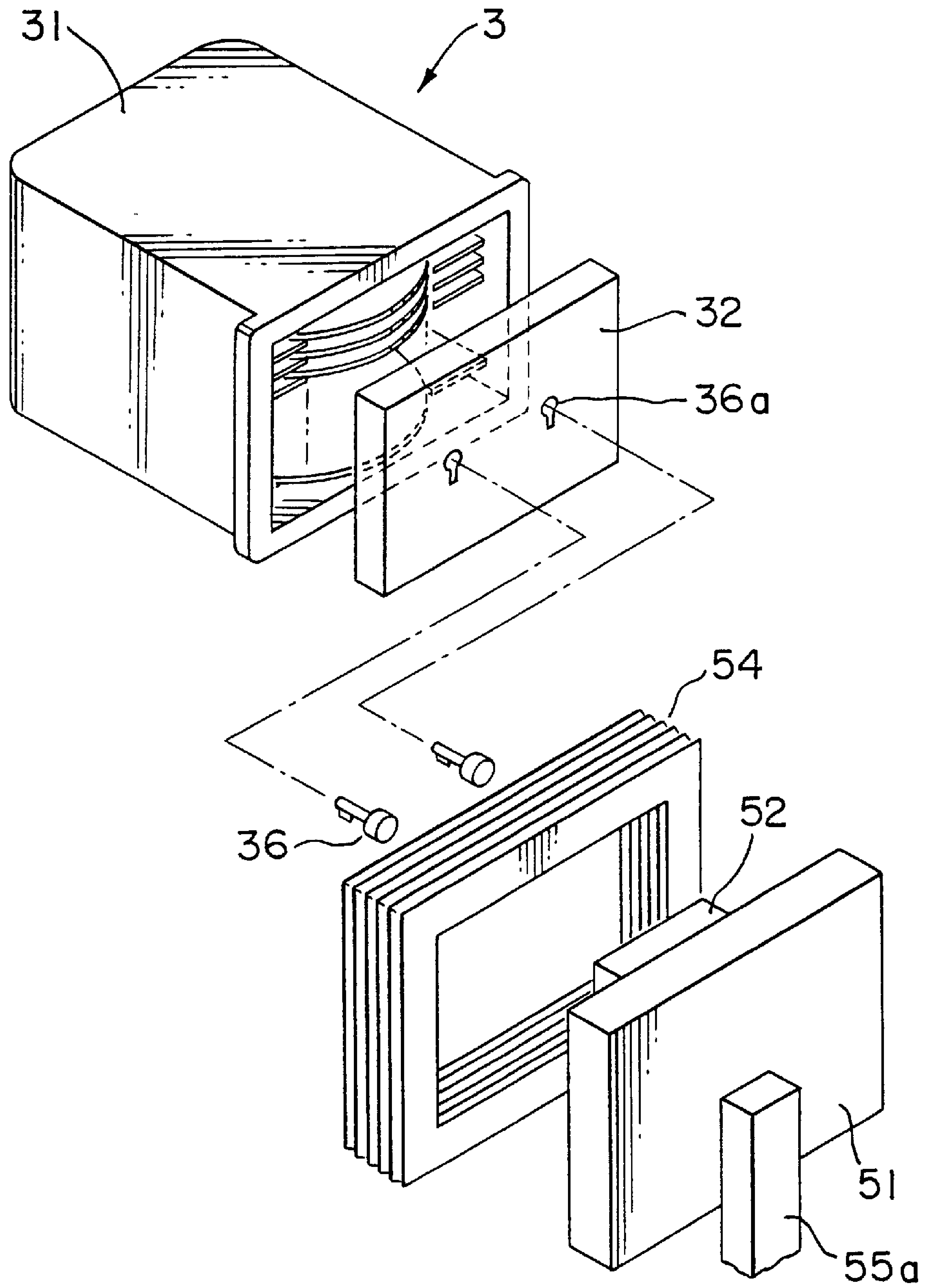

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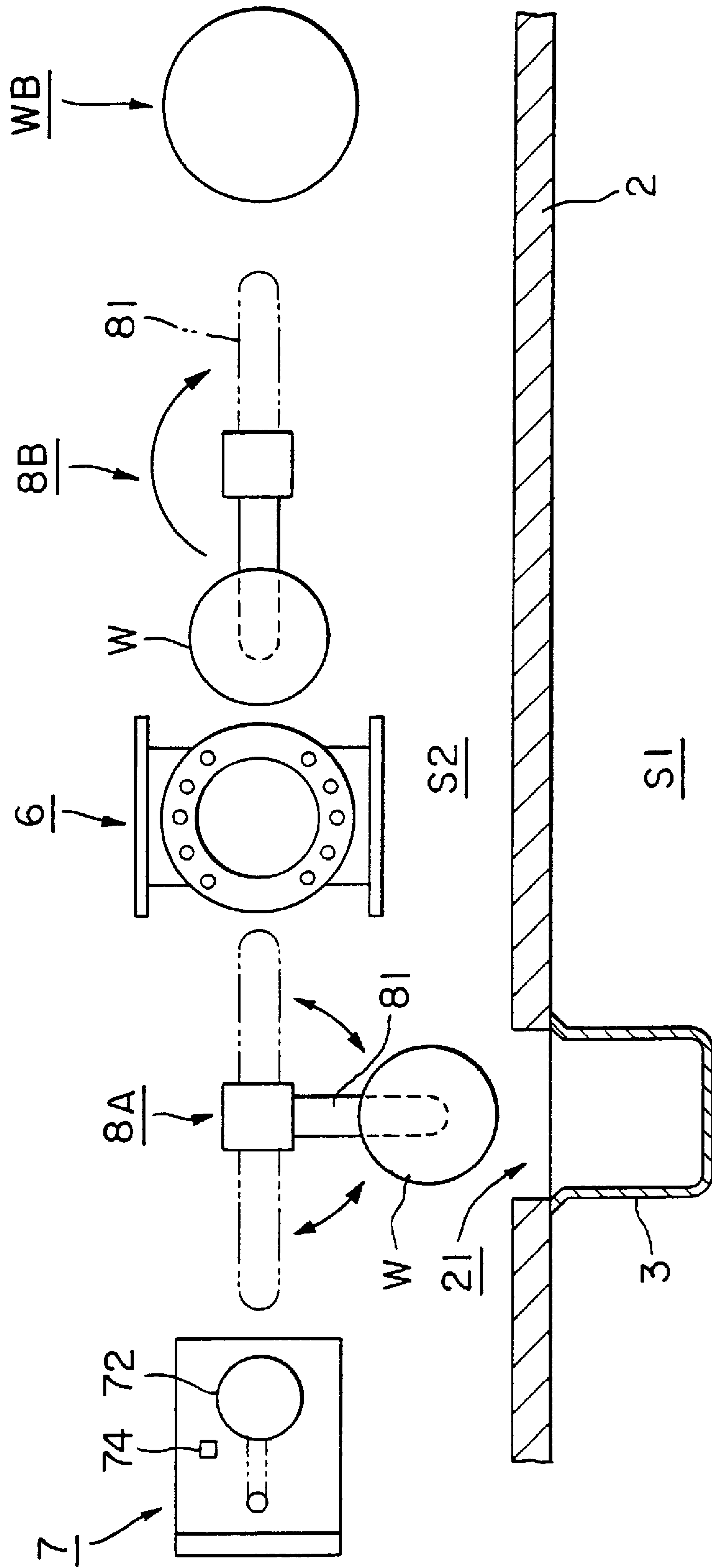


FIG. 5

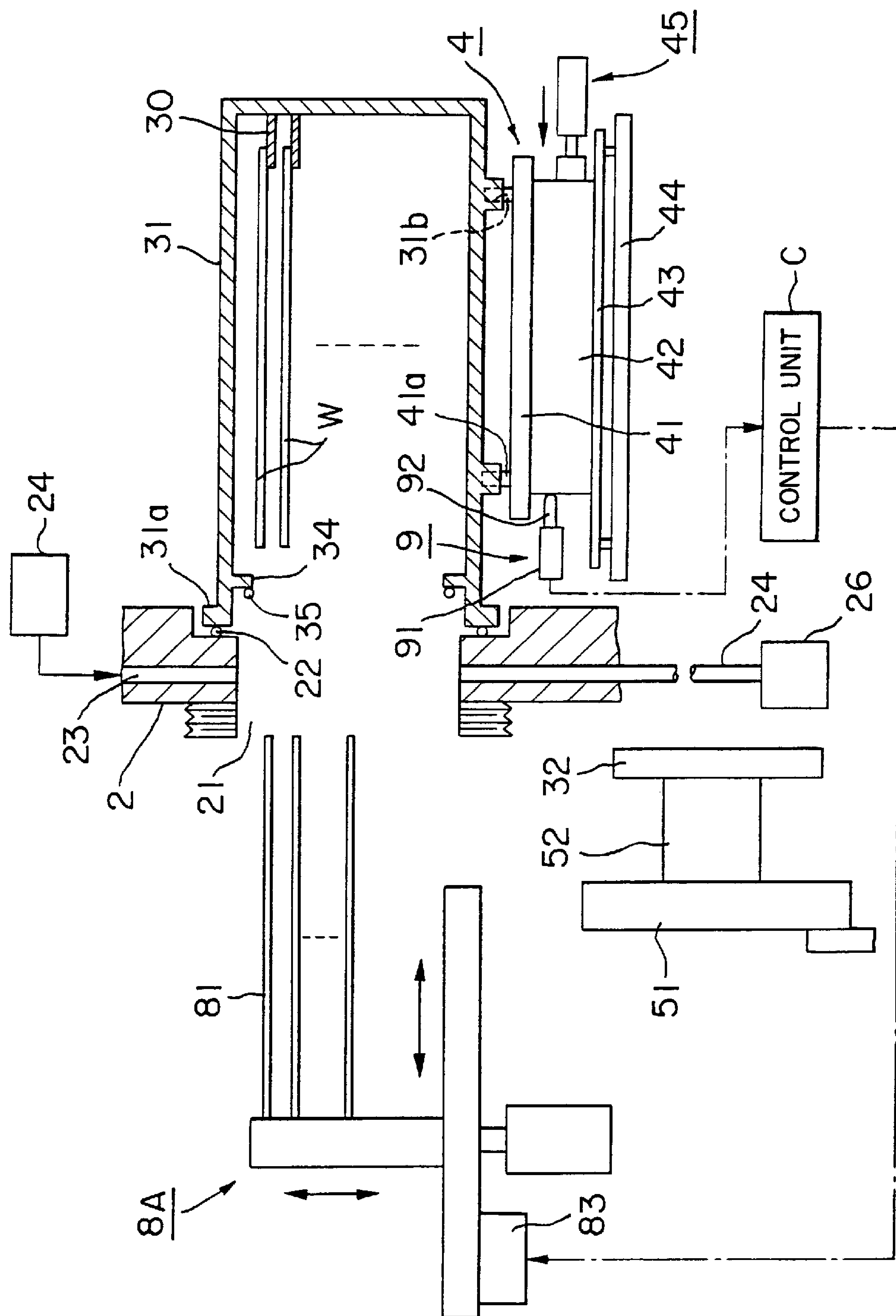


FIG. 6

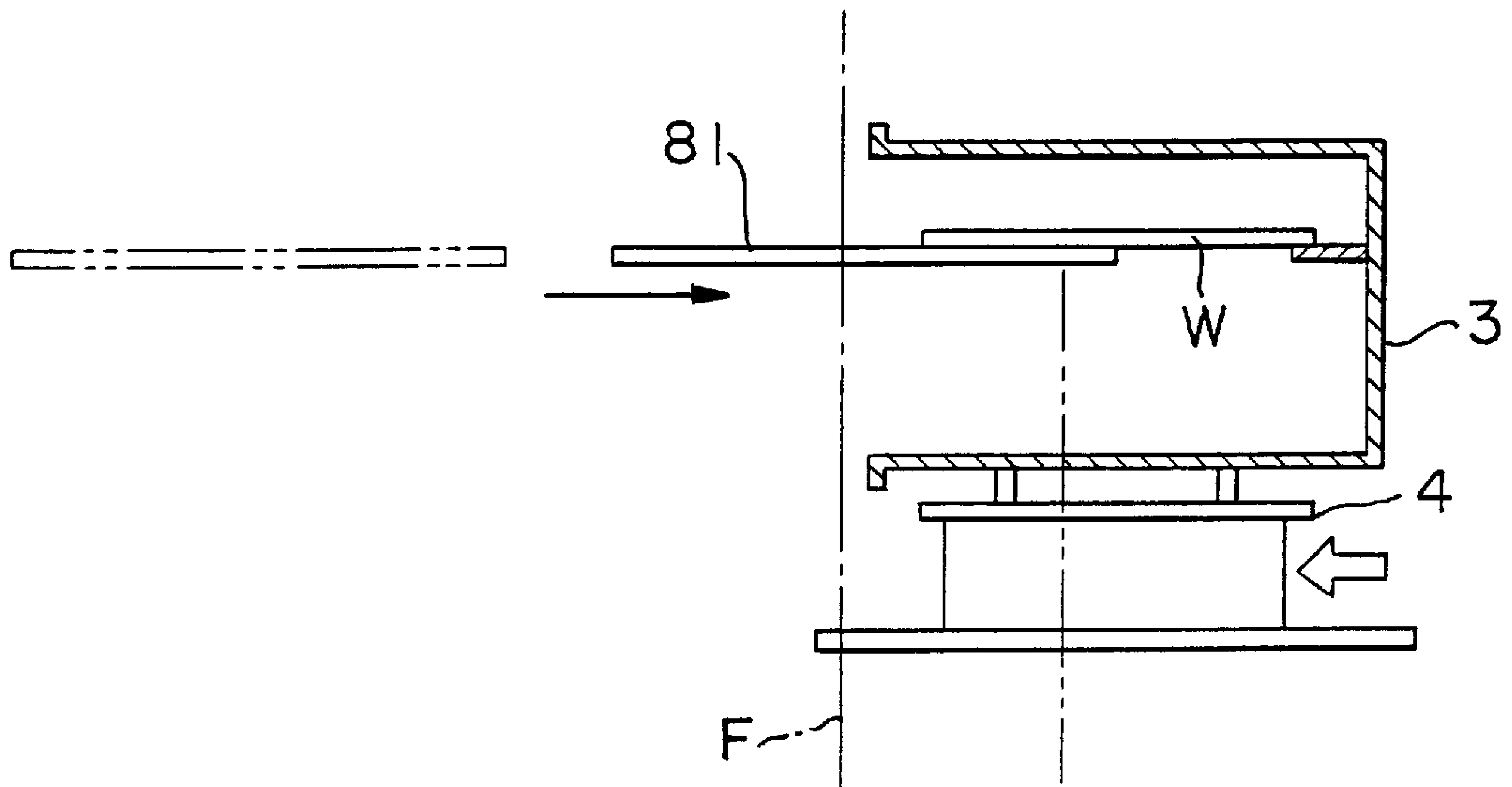


FIG. 7(a)

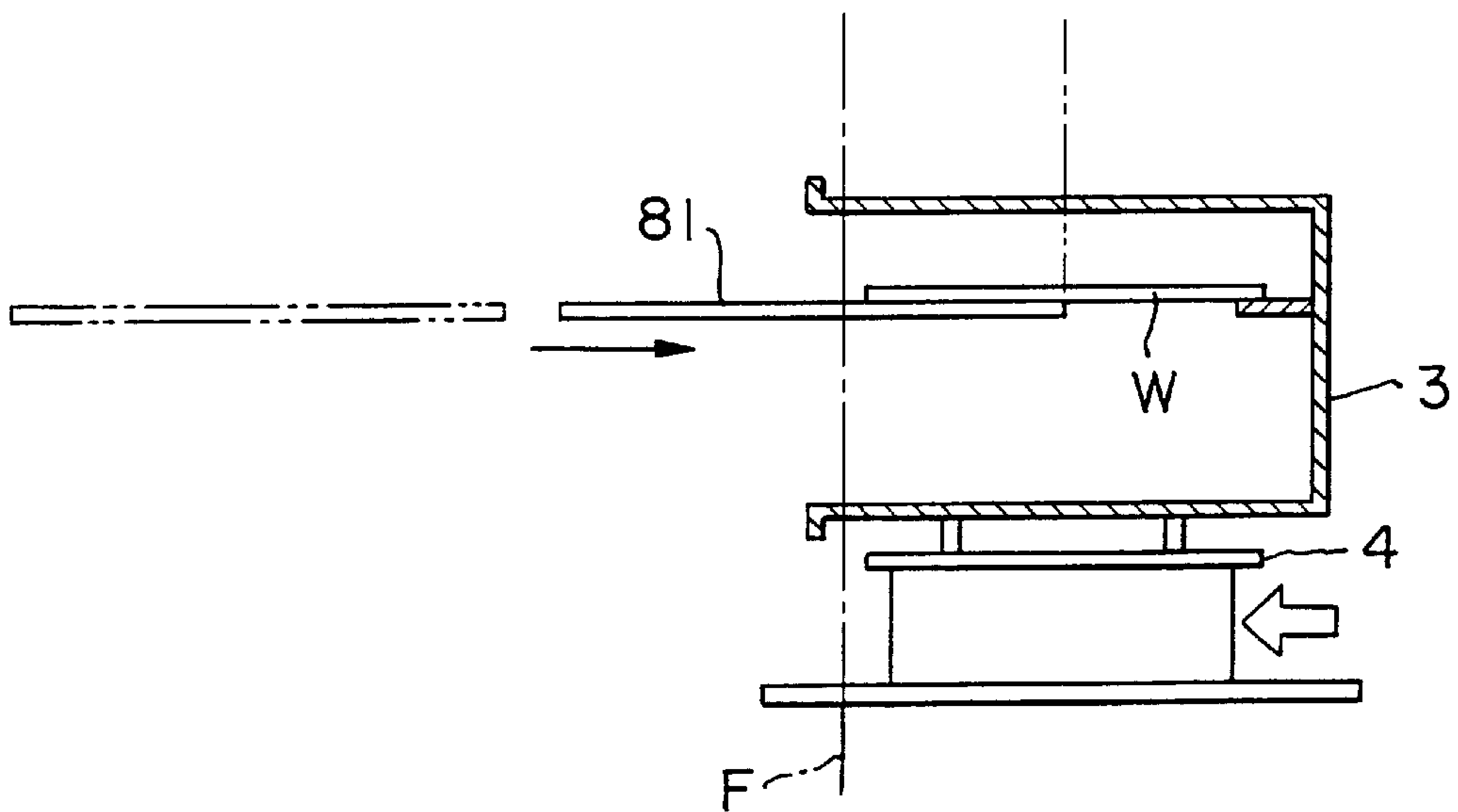


FIG. 7(b)

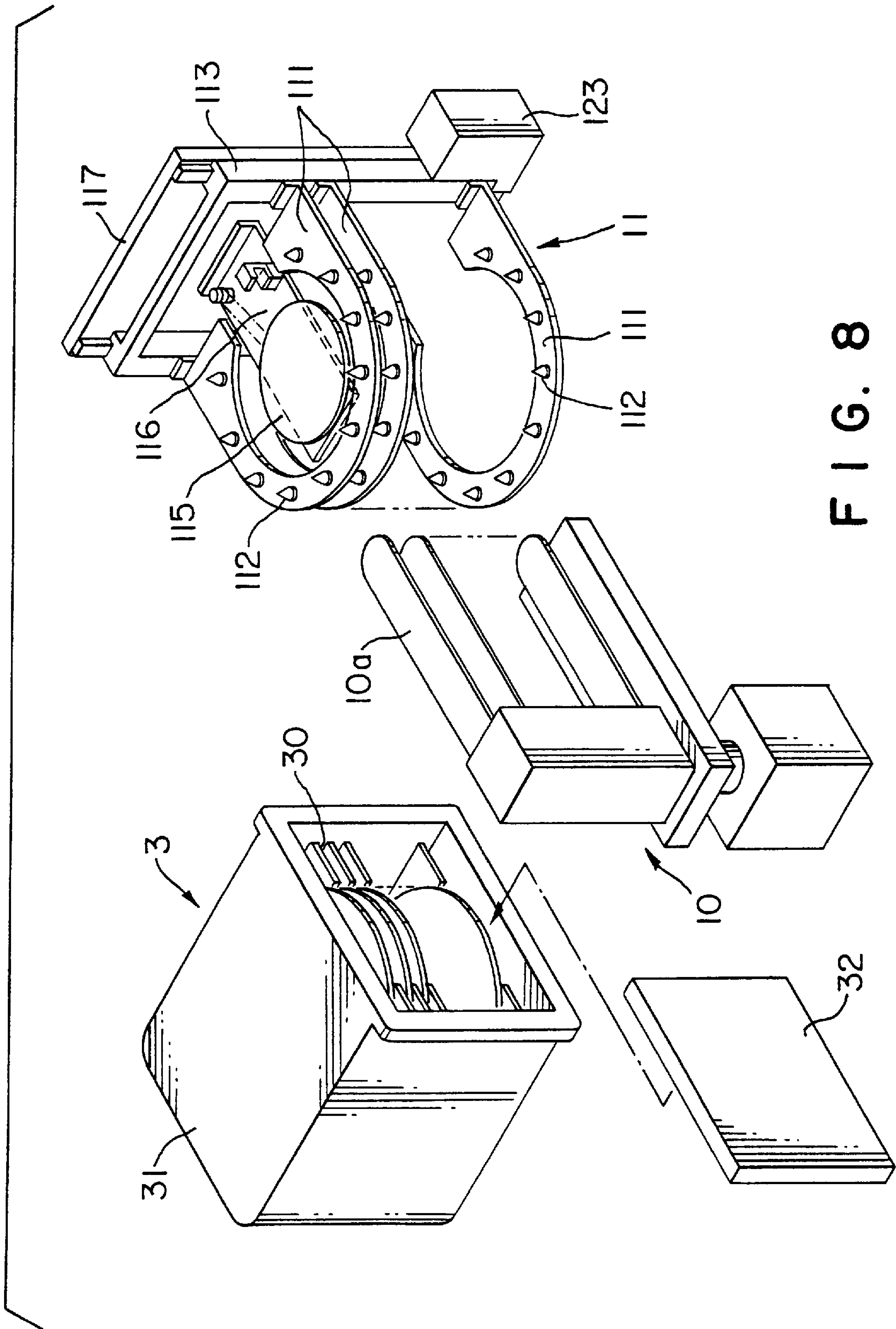
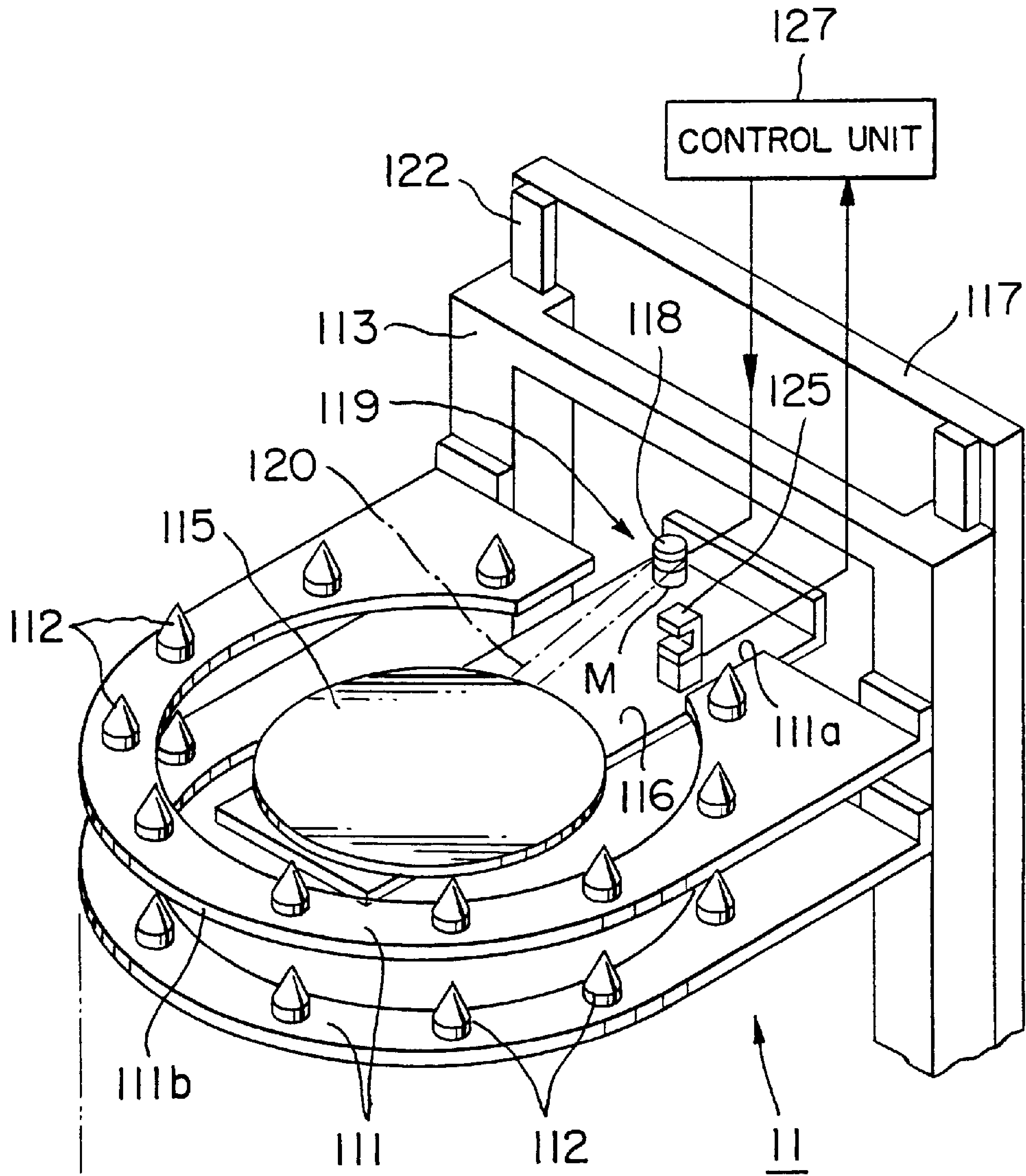


FIG. 8



F I G. 9

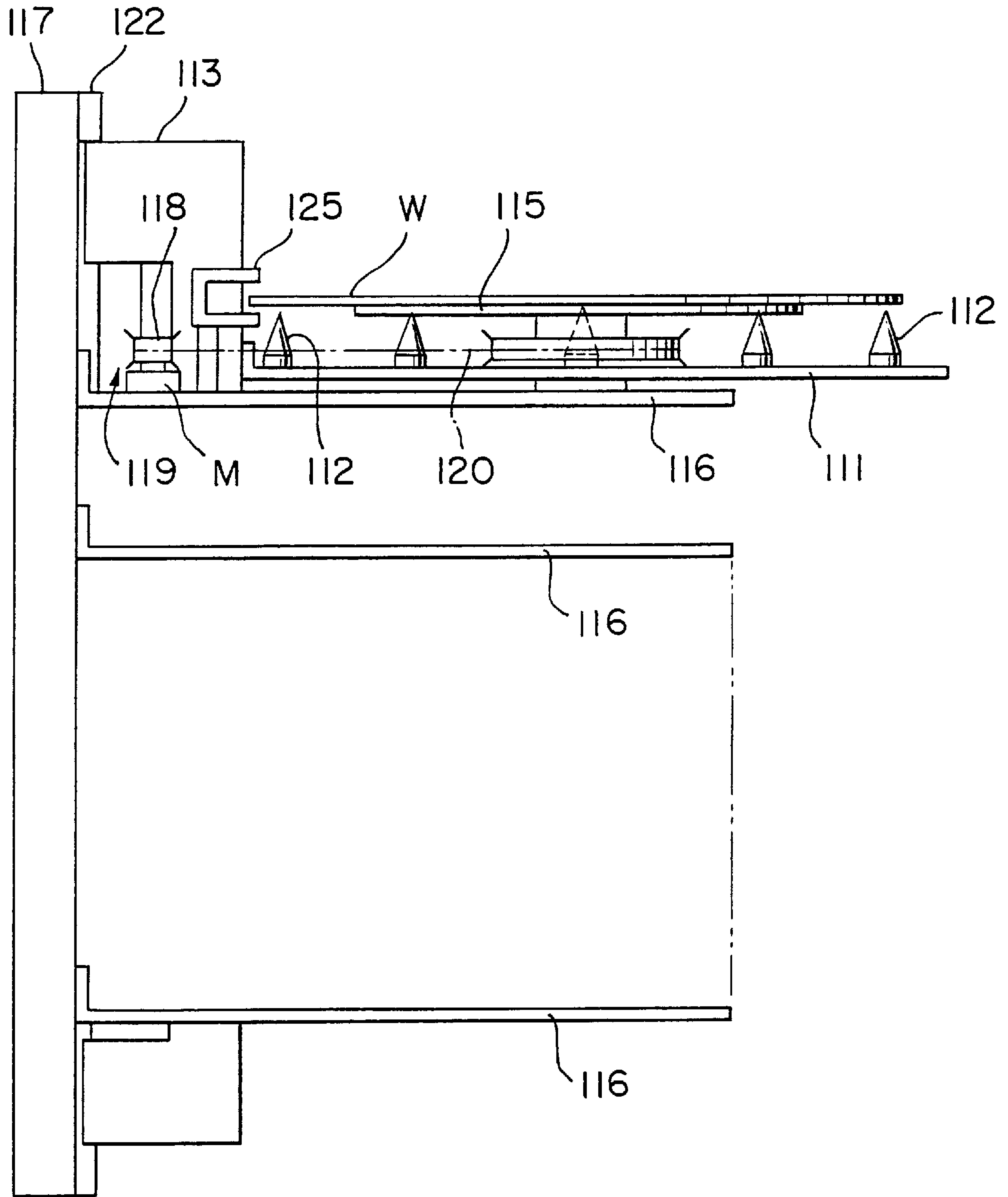


FIG. 10

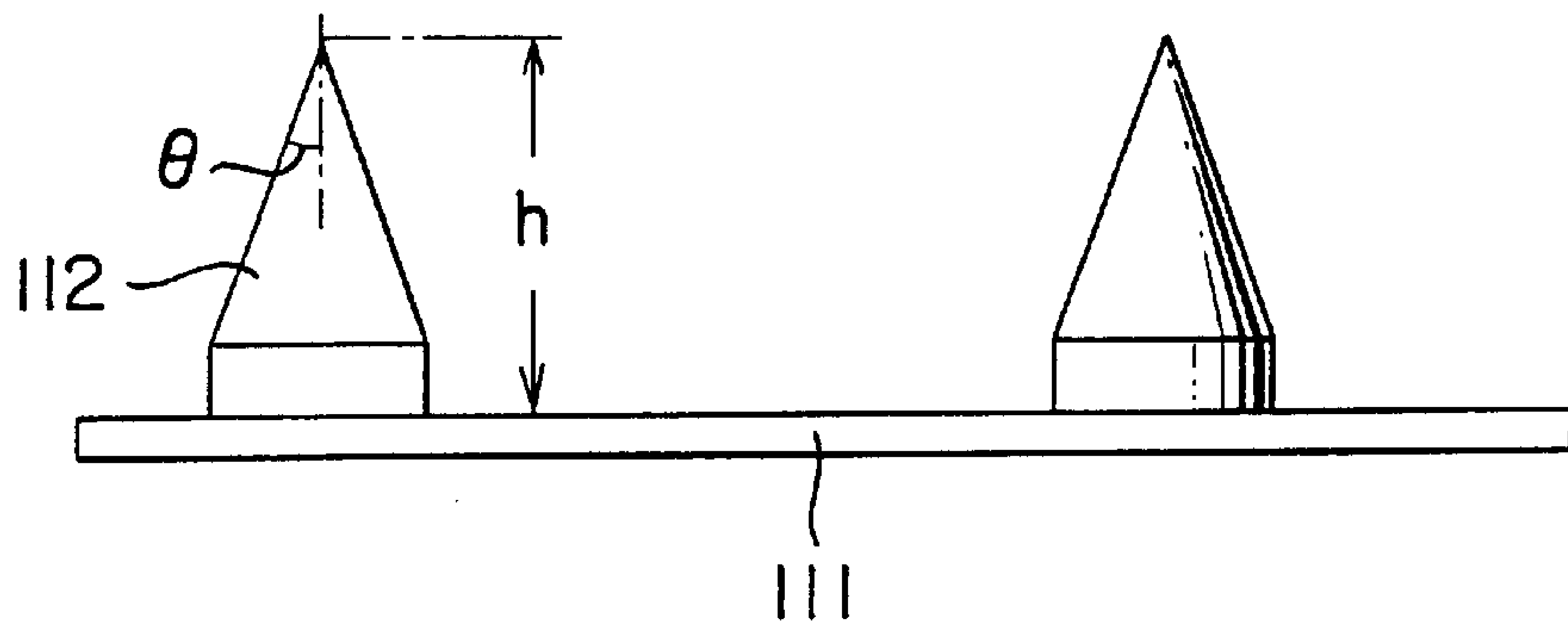


FIG. 11

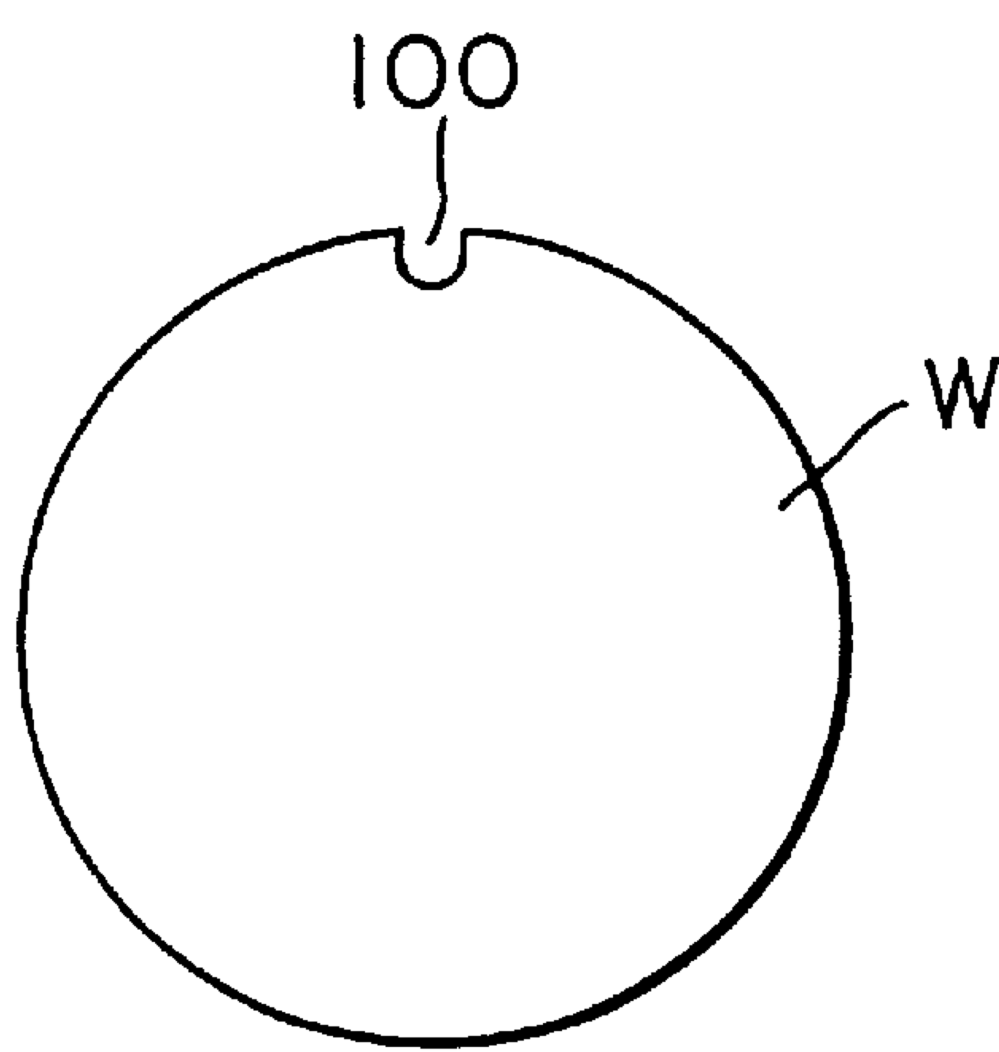


FIG. 12

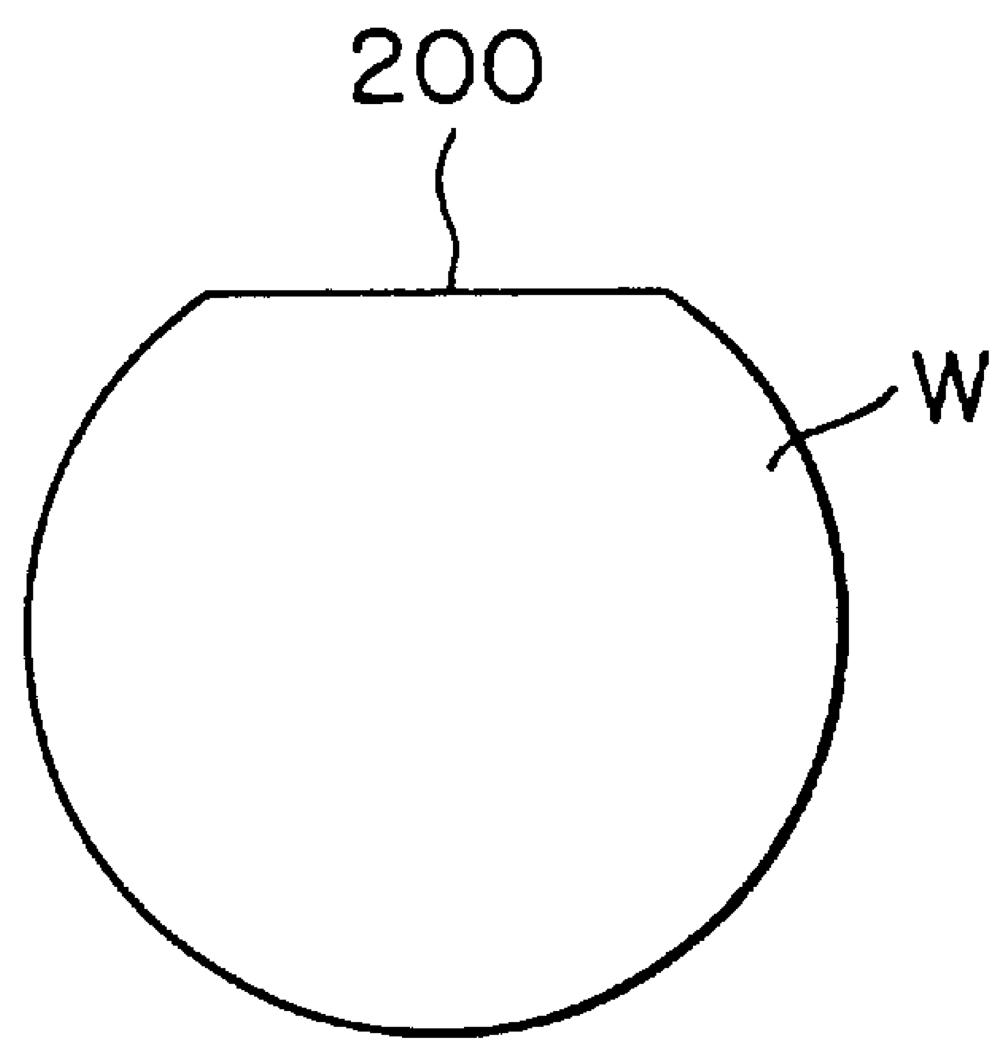


FIG. 13

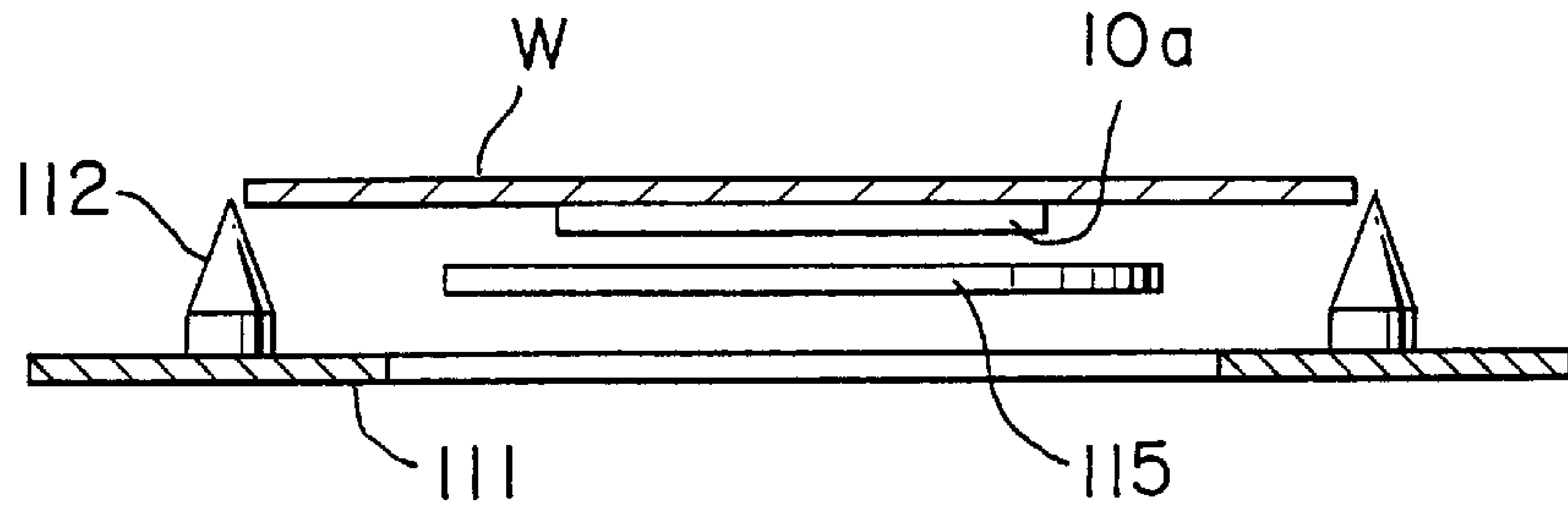


FIG. 14 (a)

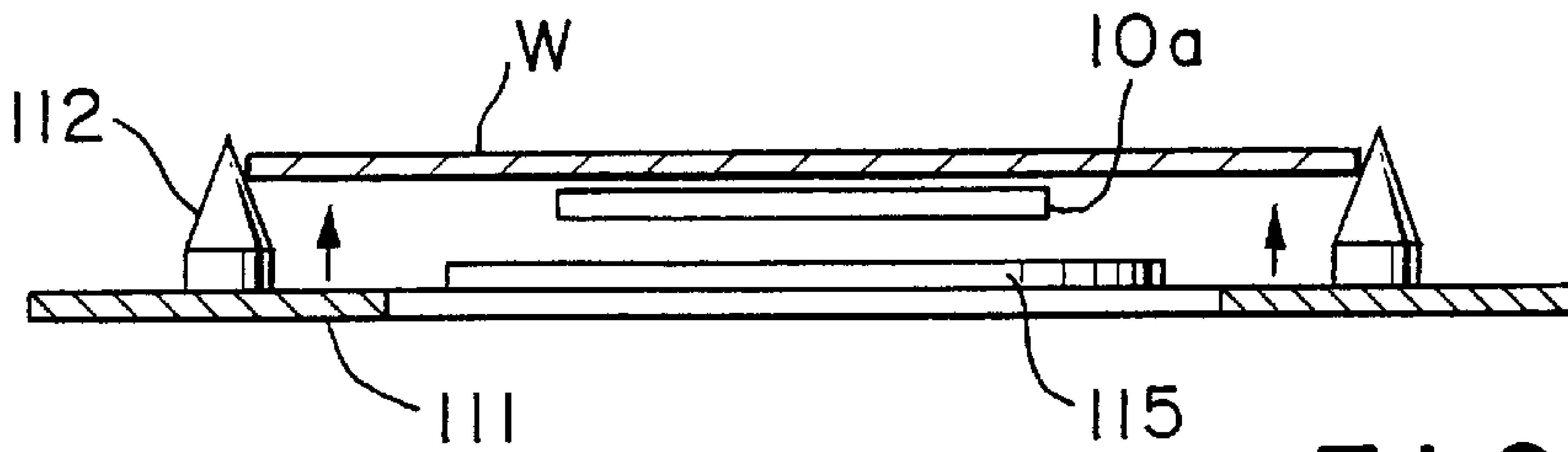


FIG. 14 (b)

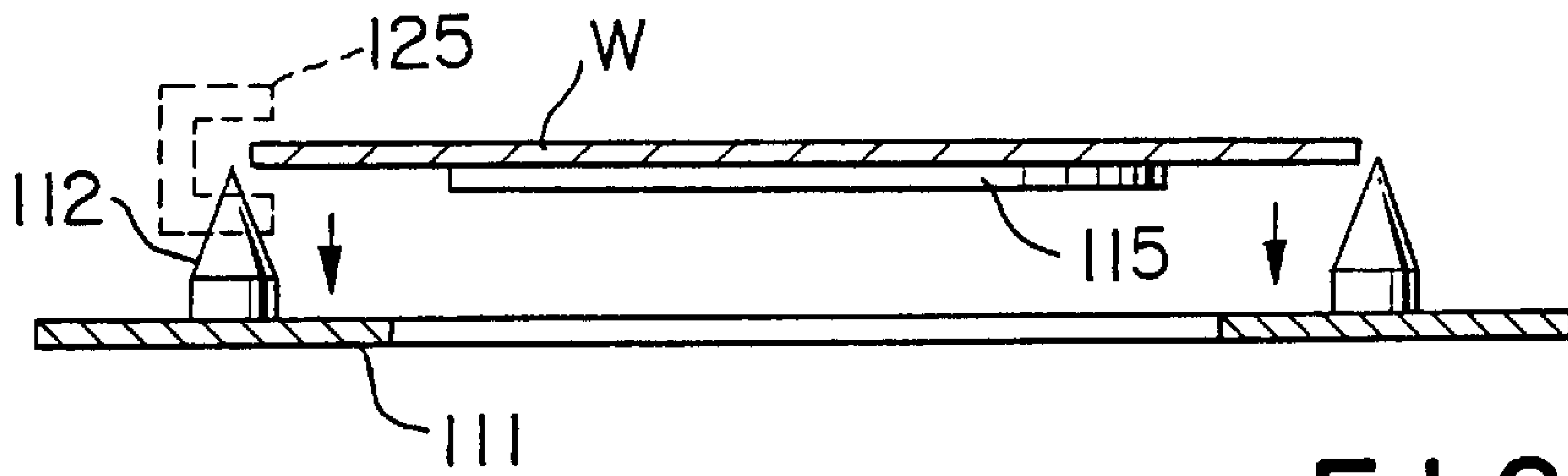


FIG. 14 (c)

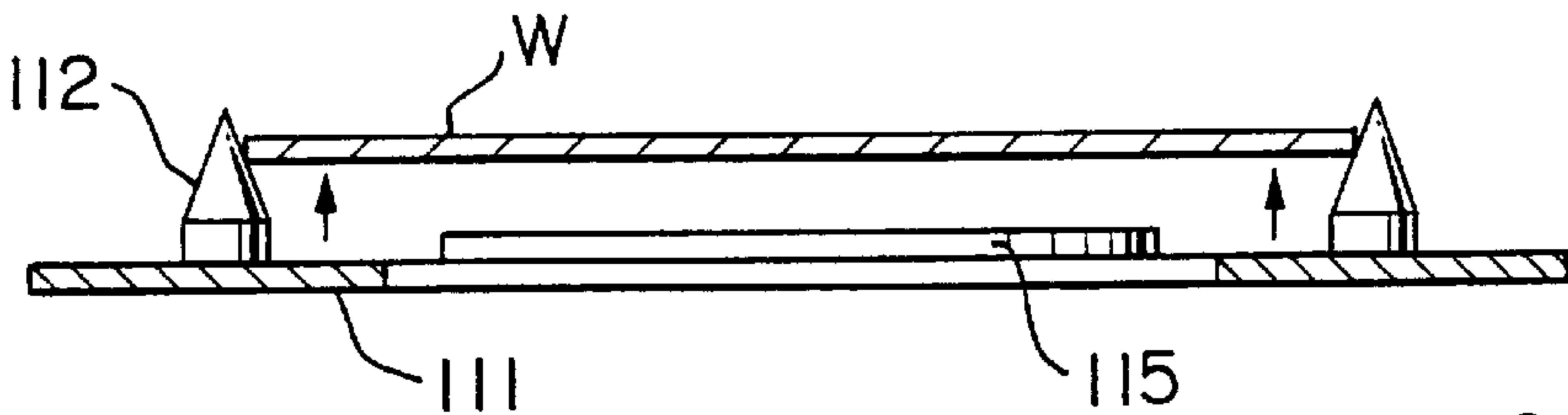


FIG. 14 (d)

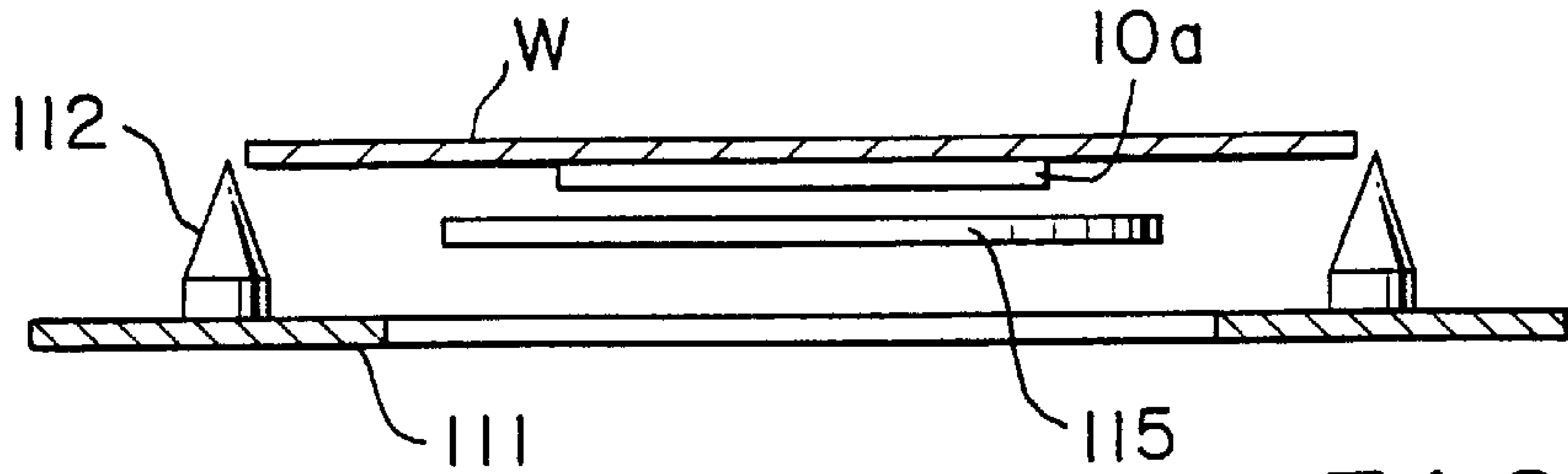


FIG. 14 (e)

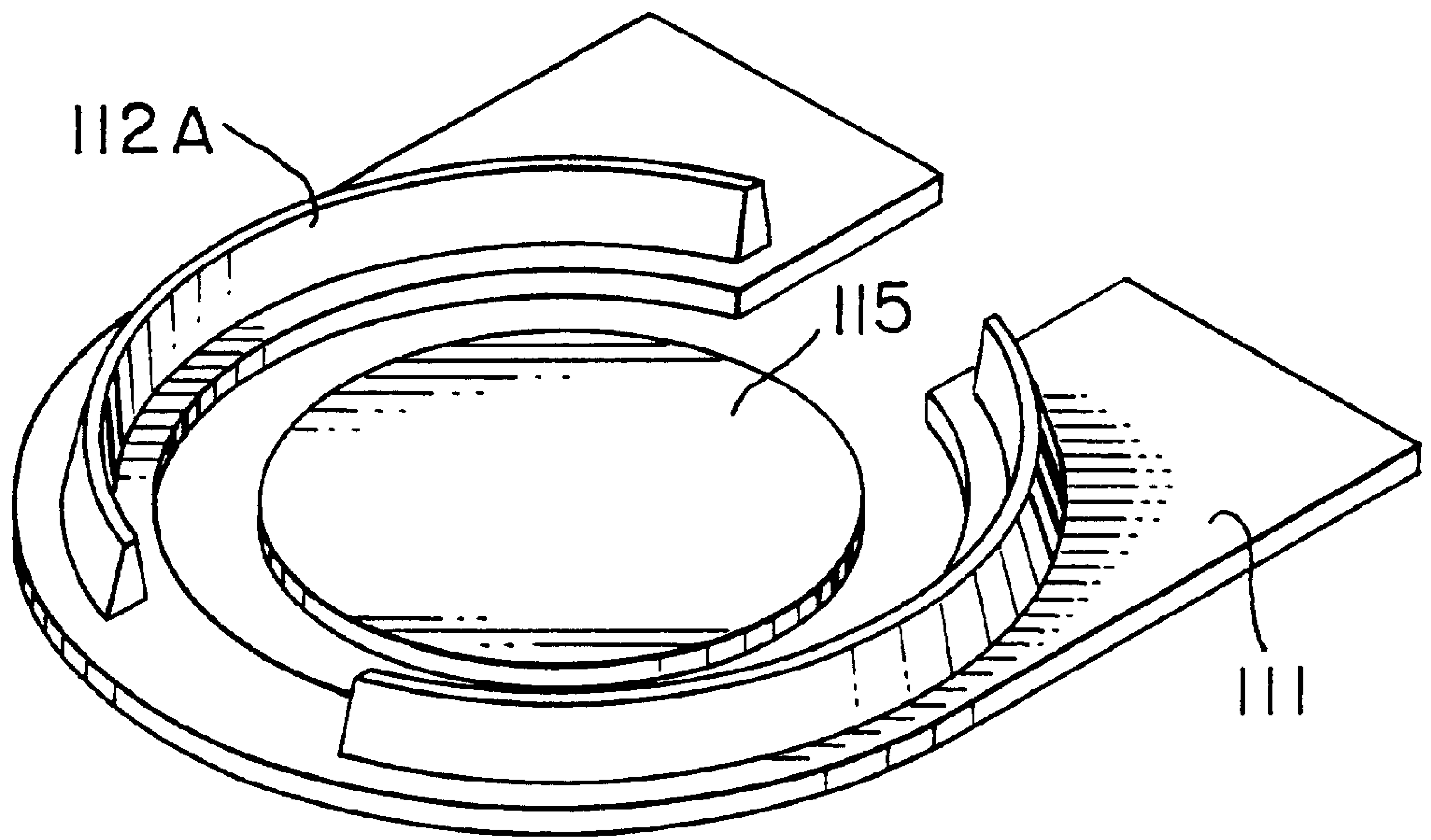
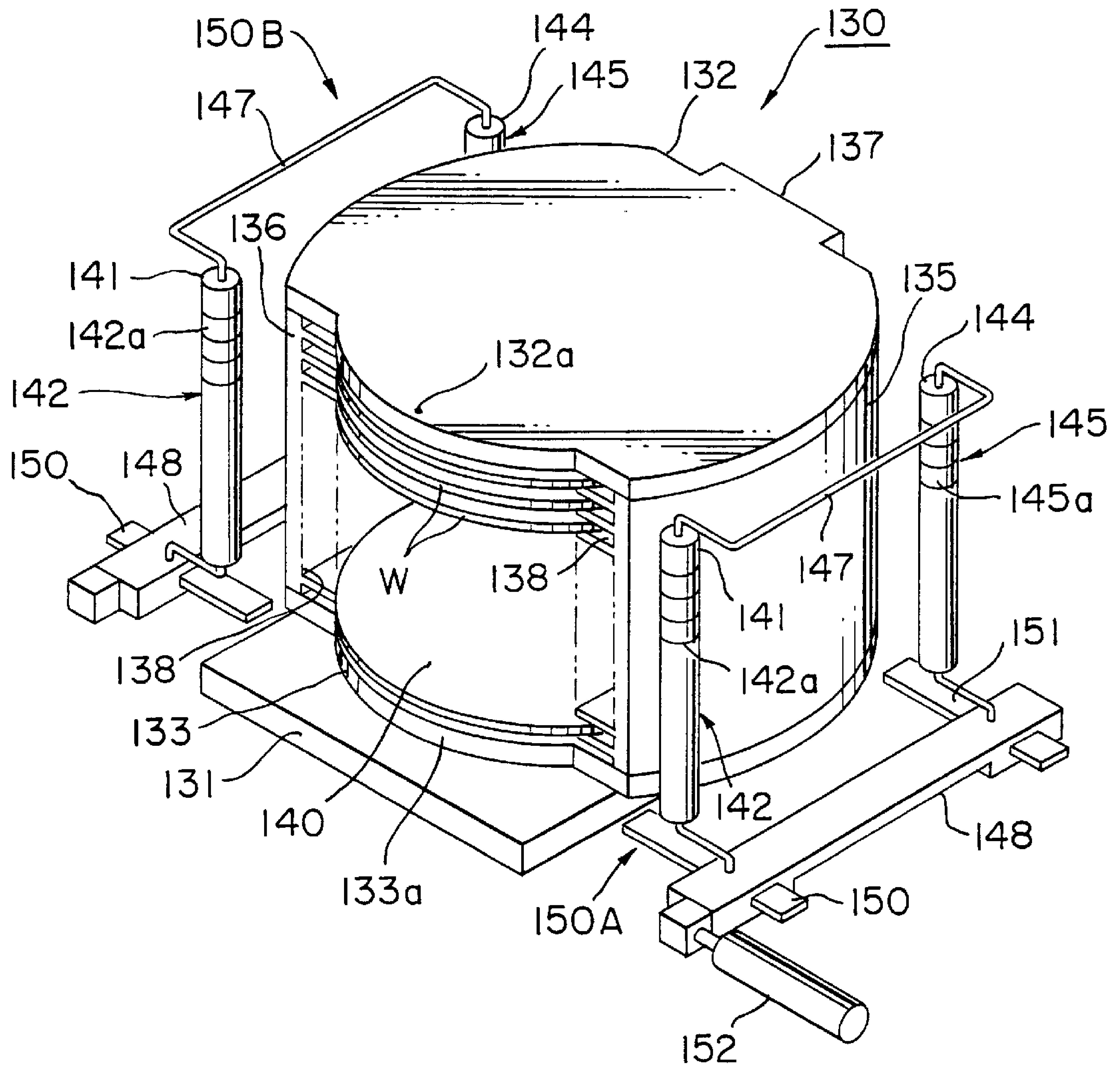


FIG. 15



F I G. 16

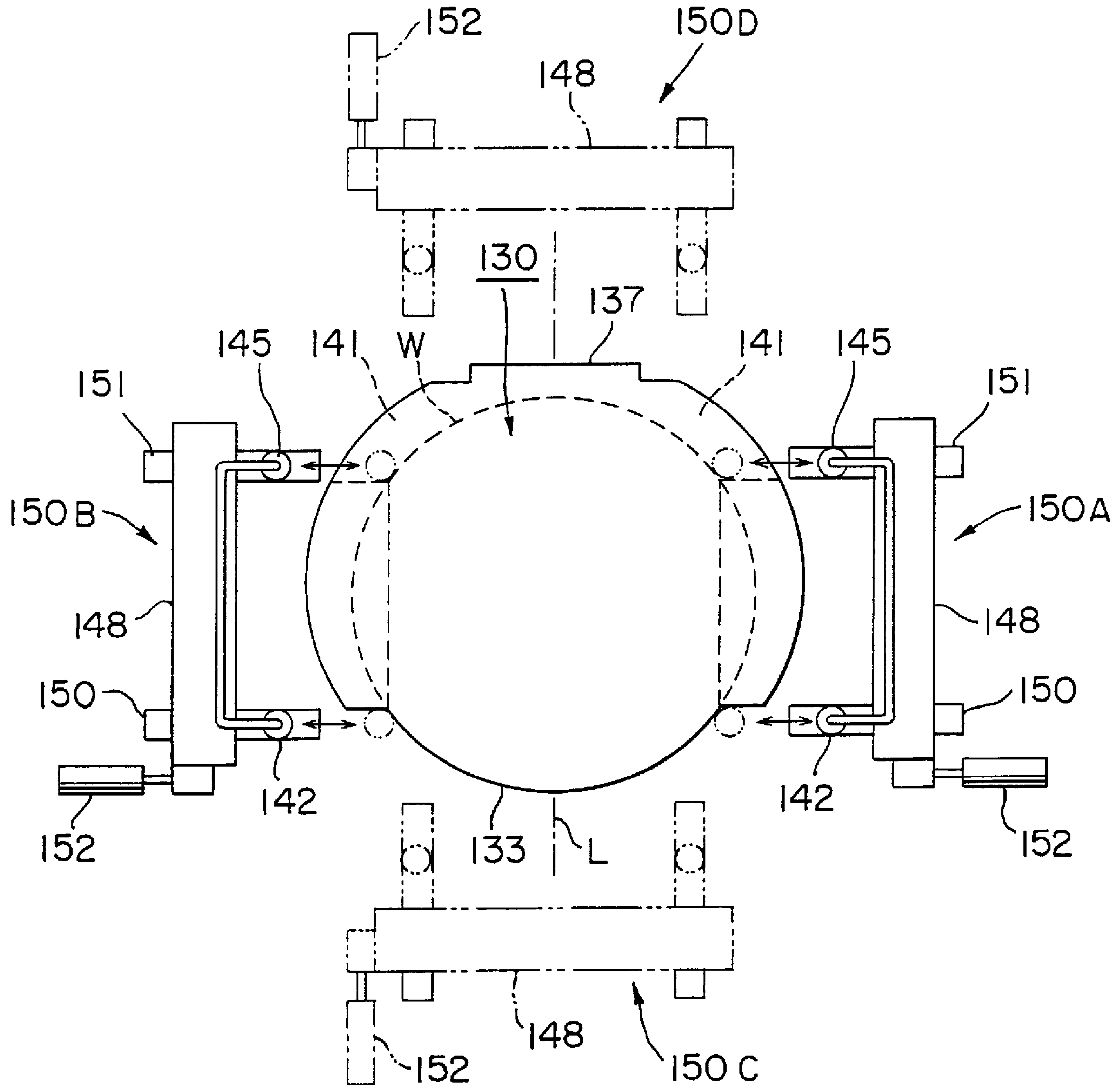


FIG. 17

POSITIONING APPARATUS FOR SUBSTRATES TO BE PROCESSED

This application is a division of U.S. application Ser. No. 08/847,721 filed Apr. 22, 1997.

The present invention relates to an apparatus for positioning a substrate to be processed such as a semiconductor wafer and, in particular, to a positioning apparatus for aligning a center and/or a rotational position of a substrate to be processed.

BACKGROUND OF THE INVENTION

In general, when a semiconductor wafer is to be processed or inspected, the orientation of the wafer must be aligned to take account of the directionality of the crystal of the wafer. For that reason, a simple method is known of forming a linear cut-out portion called an orientation flat in the wafer, to be used when the orientation flat is aligned by rollers.

This use of rollers in this manner to position the orientation flat enables wafers to be aligned in a batch while still accommodated within a cassette, and such a mechanism is used at a heat treatment station that performs a heat treatment on a batch of wafers, for example, with a cassette placed vertically to position the wafers. When a process such as ion implantation or patterning is performed on wafers, however, the wafers must be accurately placed with respect to the ion implantation region or exposure region, and thus it is necessary to center the wafers as well.

Techniques are known in the prior art as methods of positioning the orientation (the direction of the orientation flats) and the centers of the wafers, such as a technique disclosed in Japanese Patent Application Laid-Open No. 60-85536, of aligning the orientation of a wafer by a turntable and also moving that turntable in the X and Y directions to position the center thereof in a general manner, or a technique disclosed in Japanese Patent Publication No. 1-28503 of orientating a wafer on a stage by rollers and then moving that stage in the X and Y directions.

Since it is wasteful to form an orientation flat in a wafer and thus cut out a wide area thereof, a method that has recently been investigated involves forming a semicircular cut-out portion called a notch instead of a orientation flat in the peripheral edge of a wafer, and thus a mechanism that uses rollers to position wafers within a cassette cannot be applied thereto without changes.

In addition, a sealable wafer cassette has been investigated as means of suppressing contamination of the wafers by particles, but in such a case it is not possible to position the wafers within the cassette. The wafers have to be removed from the cassette for positioning, but since a plurality of wafers, such as five wafers, have to be moved at a time into a wafer boat at a heat treatment station that performs a heat treatment on a batch of wafers, for example, the previously described method of placing wafers one-by-one on a turntable would reduce the throughput.

The previously mentioned method that uses a turntable to center a wafer necessitates X-direction and Y-direction drive mechanisms and moreover the amounts of drive thereof must be accurate, so that the cost is increased by this increase in mechanical complexity. A sealed type of wafer cassette that is designed to suppress the contamination of wafers by particles is provided with a main cassette body, which accommodates a number of wafers (such as 13 wafers), and a lid member for hermetically closing a wafer transfer port formed in the main cassette body with an O-ring therebetween. The configuration is such that the lid

member is locked by, for example, the insertion of keys into the lid member, whereby it is fixed to the main cassette body.

To reduce the contamination of the wafers by particles in this case, it is preferable to partition a cassette mounting region for placing the wafer cassette from a wafer transportation region, and keep the degree of cleanliness of the cassette mounting region higher than that of the wafer transportation region. The cassette mounting region will be referred to as a first environment and the wafer transportation region will be referred to as a second environment. In one method of increasing the cleanliness of the first environment that can be considered, the first environment and the second environment are separated by a partitioning wall, the wafer cassette is attached from the first environment side to an aperture formed in the partitioning wall, and the wafers within the wafer cassette are removed toward the second environment side.

With the above-described configuration for attaching a wafer cassette, the various components are constructed in such a manner that a gap on the order of approximately 2 mm is formed between the wafer cassette and the partitioning wall at the peripheral edge portion of the aperture when the wafer cassette has been attached to the aperture in the partitioning wall. Since the pressure in the second environment is set to be higher than that in the first environment, clean air always flows into the first environment through this gap, and thus particles are prevented from penetrating from the first environment side into the second environment side.

However, the air flowing through this gap forms vortices. In the vicinity of the surfaces that define the gap, such as those of the partitioning wall and the wafer cassette, the air is extremely gentle with a velocity close to zero. Thus the air on the first environment side is entrained into the vortices of the air flowing from the second environment, so that it flows along the above surfaces into the second environment side. This causes particles to penetrate into the second environment together with the air and thus, although great care has been taken to use sealed cassettes to prevent contamination of the wafers by particles, that intention is counteracted. In addition, if the region used for transferring wafers into a wafer boat is made to be a nitrogen environment, for example, it becomes difficult to manage the oxygen density within a processing region of an apparatus designed to prevent the growth of natural oxides.

A sealed type of wafer cassette makes it impossible to position the wafers in the cassette, thus making it necessary to position the wafers after they have been removed from the wafer cassette. The exchange of wafer cassettes involves attaching the lid member to the current wafer cassette, removing the wafer cassette from the partitioning wall, and attaching a new wafer cassette to the aperture in the partitioning wall. The removal and attachment of the lid member and the removal and attachment of the wafer cassettes themselves are time-consuming processes, so that the exchange of wafer cassettes takes a long time. Therefore, since the incorporation of a system that uses a sealed type of wafer cassette makes it necessary to add the time required for positioning the wafers and the time required for exchanging the wafer cassettes, there are demands for the investigation of techniques preventing any deterioration in throughput.

SUMMARY OF THE INVENTION

The present invention was devised in the light of these problems in the prior art and has as an object thereof the provision of a positioning apparatus that enables simple

alignment of the center and/or the orientation of a substrate to be processed, such as a wafer.

Another object of the present invention is to provide a positioning apparatus that enables alignment of the center and/or the orientation of a plurality of substrates to be processed at a time.

A further object of the present invention is to provide a positioning apparatus that enables centering of a substrate to be processed within a cassette for substrates to be processed.

A still further object of the present invention is to provide an apparatus for transporting a substrate to be processed that suppresses any decrease in the cleanliness of a region in which the substrate to be processed is mounted, when a sealed type of cassette for substrates to be processed is used to transport the substrate to be processed.

A yet further object of the present invention is to provide an apparatus for transporting a substrate to be processed which is capable of improving throughput when a sealed type of cassette for substrates to be processed is used to transport the substrate to be processed.

The present invention provides in one aspect thereof an apparatus for aligning a central position and a rotational position of a substrate to be processed, where the substrate has a peripheral edge forming a circle and a cut-out portion for rotational position detection formed in the peripheral edge; wherein the apparatus comprises a turntable which is rotatable about a vertical rotational axis and which has an upper surface on which a substrate to be processed is mounted; detection means for detecting the cut-out portion of the substrate that is mounted on and rotating with the turntable; control means for controlling an amount of rotation of the turntable in accordance with a detection signal from the detection means, to align the rotational position of the substrate to be processed; a horizontal base for receiving a substrate to be processed; and inclined guide means rising from an upper surface of the base and provided along a circular peripheral edge of the substrate to be processed, the guide means being mounted on the base, in such a manner that the peripheral edge of the mounted substrate to be processed comes into contact therewith and is guided thereby; the guide means comprising a taper that is inclined in such a manner as to separate from the substrate to be processed with increasing upward distance.

The present invention provides in another aspect thereof an apparatus for positioning a substrate to be processed, comprising support means for supporting a plurality of substrates to be processed at intervals in a vertical direction; and pushing means provided outside the support means for pushing outer peripheral edges of substrates to be processed that are exposed from the support means, from the outside in at least three locations, to position the substrates to be processed.

The present invention provides in a further aspect thereof a transporting apparatus for a substrate to be processed, comprising a partitioning wall for demarcating a first environment from a second environment, and having an aperture for transfer of a substrate to be processed; a sealed type of cassette for substrates to be processed, comprising a main cassette body having an aperture through which a substrate to be processed enters or exits and a lid member for closing the aperture of the main cassette body; cassette mounting means provided within the first environment, for supporting the cassette in such a manner that the aperture for substrates to be processed is aligned with the transfer aperture of the partitioning wall; sealing means for forming a seal between the peripheral edge of the transfer aperture of the partitioning wall and the peripheral edge of the aperture of the main cassette body, to hermetically demarcate a space within the cassette from the first environment; means for positioning a substrate to be processed, provided within the second environment; a substrate transporting mechanism provided within the second environment; a lid member for the partitioning wall for closing the transfer aperture of the partitioning wall in an openable manner; first opening/closing means for opening or closing the partitioning wall lid member; and second opening/closing means for opening or closing a lid member of the cassette.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic perspective view of a substrate transporter apparatus provided with an apparatus for positioning a substrate to be processed in accordance with this invention;

FIG. **2** is a cross-sectional view, mainly of the components of a wafer cassette shown in FIG. **1**;

FIG. **3** is a perspective view of the wafer cassette;

FIG. **4** is a perspective view of the wafer cassette, sealing member, second opening mechanism, and lid member for the wall;

FIG. **5** is a plan view used to illustrate the operation of the wafer transporter apparatus;

FIG. **6** is a sectional view through another embodiment of the present invention relating to a wafer cassette and wafer transporter apparatus;

FIGS. **7**(*a*) and **7**(*b*) are views illustrative of the operation of the apparatus of FIG. **6**;

FIG. **8** is a schematic perspective view of part of a transporter station that comprises a positioning apparatus of an embodiment of this invention;

FIG. **9** is an enlarged perspective view of part of FIG. **8**;

FIG. **10** is a side view of FIG. **9**;

FIG. **11** is a side view of tapered pins of the positioning apparatus, shown enlarged;

FIGS. **12** and **13** are plan views of different types of wafer;

FIGS. **14**(*a*) to **14**(*e*) are views sequentially illustrating the state of positioning of a wafer;

FIG. **15** is a perspective view of a variant of the tapered guide means;

FIG. **16** is a perspective view of yet another embodiment of the positioning apparatus; and

FIG. **17** is a plan view of the positioning apparatus of FIG. **16**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A representative embodiment of the present invention is shown in FIG. **1** and a section through a main portion thereof is shown in FIG. **2**. This device is demarcated by a partitioning wall **2** to form a first environment **S1** that is a wafer cassette mounting region and a second environment **S2** that is a wafer transportation region. An aperture **21** for the transfer of wafers, which are substrates to be processed, is formed in this partitioning wall **2** as shown in FIG. **2**, and a step portion **21***a* is formed around a peripheral edge portion on the first environment **S1** side of the aperture portion **21**.

An O-ring **22** formed of a resilient material such as Teflon (tradename) is provided on a step surface of the step portion **21***a* (hereinafter called a surface facing an attachment/

removal direction), to form a sealing portion. This O-ring **22** is designed to provide a seal between a peripheral edge portion of a wafer cassette **3** and the aperture **21** of the partitioning wall **2**, thus hermetically separating the first environment S1 from a space within the wafer cassette **3**. A nitrogen (N2) gas supply passage **23** and an exhaust passage **24**, are provided in such a manner as to open into an inner peripheral surface of the partitioning wall **2** surrounding the aperture **21**, and a N2 gas source **25** and a vacuum pump **26** are connected to the other ends of the N2 gas supply passage **23** and exhaust passage **24**, respectively.

The sealed wafer cassette **3**, which is a cassette for substrates to be processed, is hermetically attached to the partitioning wall **2** on the first environment S1 side of the aperture **21**. This wafer cassette **3** is provided with a main cassette body **31** in which are formed multiple stages of wafer holder portions **30** in such a manner that a number of wafers W (for example, 13 wafers), which are substrates to be processed, are supported vertically at a certain spacing thereby, and a lid member **32** for hermetically sealing an aperture **33** that is a wafer transfer port of this main cassette body **31**, as shown by way of example in FIG. **3**.

The lid member **32** is provided in such a manner that it enters within the aperture **33** of the main cassette body **31**, a protruding portion **34** that acts as a stopper for the lid member **32** is formed around the inner peripheral surface of the main cassette body **31**, and an O-ring **35** is provided between the lid member **32** and the protruding portion **34**, as shown in FIG. **2**. As shown in FIG. **3**, keyholes **36***a* are provided in, for example, two locations on the lid member **32** and the configuration is such that a number of locking pins **37** (for example, four pins) are forced outward from the upper and lower edges of the lid member **32** to fix together the main cassette body **31** and the lid member **32**, by inserting keys **36** that are provided in a second opening mechanism (which will be described later) into the keyholes **36***a* and rotating the same. The peripheral edge portion of the aperture **33** of the main cassette body **31** is formed as a flange portion **31***a* with the outer side thereof being curved.

The wafer cassette **3** is mounted on a stage **41** (FIG. **2**) of a cassette mounting portion **4**, the wafer cassette **3** is supported by this cassette mounting portion **4** at a position aligned with the aperture **21** for the transfer of wafers, and is attached to the aperture **21** for the transfer of wafers in such a manner that the flange surface of the flange portion **31***a* is placed in hermetic contact with the step surface of the step portion **21***a* of the aperture portion **21** for the transfer of wafers, with the O-ring **22** therebetween. For the sake of convenience, the partitioning wall **2** and the cassette mounting portion **4** are drawn in FIG. **1** displaced to the left from their normal positions, but in practice these components are positioned towards the side of a first transporter mechanism **8**A, which will be described later.

The cassette mounting portion **4** is provided with the stage **41** on which are formed a number of protrusions **41***a* (for example, four protrusions), a stage-supporting stand **42** for supporting the stage **41**, and guide rails **43** provided on a base **44** in a direction in which the wafer cassette **3** is attached and removed. The stage-supporting stand **42** is configured to be capable of moving along the guide rails **43** in this attachment/removal direction of the wafer cassette **3**.

Indentations **31***b* are formed in a lower surface of the wafer cassette **3** to match the protrusions **41***a* of the stage **41**, with the configuration being such that the wafer cassette **3** is positioned on the stage **41** by the engagement of the indentations **31***b* with the protrusions **41***a*. A pushing mechanism **45** such as an air cylinder, for pressing the stage-supporting stand **42** towards the partitioning wall **2** side, is provided on a rearward side (opposite to the second environment S2) of the stage-supporting stand **42**.

A lid member **51** for the partitioning wall **2**, for hermetically closing the second environment S2 side of the aperture portion **21** for the transfer of wafers, is provided on the second environment S2 side of the aperture portion **21** of the partitioning wall **2**, as shown by way of example in FIG. **4**. This lid member **51** is formed to be of a size that covers the peripheral edge-portion of the aperture **21** on the second environment S2 side and is configured to be opened and closed by a first opening mechanism. This first opening mechanism is provided with an elevator base **55** for raising and lowering the lid member **51** by an elevator shaft **55***a*, and a horizontal base **56** for causing the elevator base **55** to move horizontally.

A second opening mechanism **52** for opening and closing the lid member **32** of the wafer cassette **3** is provided in combination with the lid member **51**, and this second opening mechanism **52** has a key manipulation mechanism **53** (see FIG. **2**) that moves the keys **36** forward and backward, and rotates them. A freely extendable bellows-like sealing member **54** is fixed by suction pads to the peripheral edge portion of the aperture **21** on the second environment S2 side in such a manner as to hermetically close the peripheral edge portion of the wall lid member **51**.

The mechanism for transporting and positioning the wafers in the second environment S2 will now be described with reference to FIG. **1**. Within the second environment S2 are provided an intermediate transfer stand **6** for temporary placement of the wafers; a positioning mechanism **7** for positioning wafers disposed on a forward upper side thereof; a wafer boat WB or the like that forms part of a thermal processing station disposed on a rearward side of the intermediate transfer stand **6**; the first transporter mechanism **8**A for transferring wafers to and from the wafer cassette **3**, the intermediate transfer stand **6**, and the positioning mechanism **7**; and a second transporter mechanism **8**B for transferring wafers to and from the intermediate transfer stand **6** and the wafer boat WB.

The intermediate transfer stand **6** is combined with a mechanism for positioning the centers of the wafers W and is provided with mounting rings **61** for positioning the centers of the wafers, disposed in 65 stages so as to be capable of accommodating more wafers than those in one cassette (13 wafers), such as the contents of five cassettes. Each of the mounting rings **61** is provided with a number of conical tapered. pins **62**, such as ten pins, disposed symmetrically five on each side along positions corresponding to the periphery of the wafer W. Spaces for the insertion of the first transporter mechanism **8**A and the second transporter mechanism **8**B are formed between pairs of the tapered pins **62** at the forward and rearward sides.

The positioning mechanism **7** is provided with a plurality of fixed bases **71** (such as five). Each of these fixed bases **71** is provided with a turntable **72**, which supports the rear surface of a wafer W and is rotated about a vertical axis by a drive portion **73**, and an optical sensor **74** for detecting a notch or orientation flat of the wafer on the turntable **72**. The positioning mechanism **7** controls the angle of rotation of the turntable **72** on the basis of a detection signal from the optical sensor **74**, to align the wafer in a predetermined orientation.

Each of the first transporter mechanism **8**A and the second transporter mechanism **8**B is provided with, for example,

five transporter arms **81** that are capable of transporting a plurality of wafers, such as five wafers, at a time or a single wafer at a time. These arms are configured to be freely movable forward/backward, vertically, and rotatably, and the pitch (vertical spacing) therebetween is also variable.

The operation of this embodiment will now be described. First of all, a wafer cassette **3** containing wafers W is mounted on the cassette mounting portion **4** and it is pushed by the pushing mechanism **45**. This presses the flange surface of the flange portion **31***a* of the wafer cassette **3** against the step surface of the step portion **21***a* of the aperture **21** for the transfer of wafers, with the O-ring **22** therebetween, to form a hermetic seal between the first environment S1 and the second environment S2.

A pure inert gas such as N2 is then supplied from the N2 gas supply passage **23** into the space within the aperture **21** of the partitioning wall **2** (between the lid member **51** for the wall and the wafer cassette **3**) while the pressure within the aperture **21** is reduced to, for example, 0.07 MPa by the vacuum pump **26** through the exhaust passage **24**, to replace the air within that space with N2. The keys **36** of the key manipulation mechanism **53** of the second opening mechanism **52** are then inserted into the keyholes **36***a* of the lid member **32** of the wafer cassette **3** and rotated, whereby the locking pins **37** are released, closing the lid member **32**.

Subsequently, the lid member **51** of the wall is moved backwards by the horizontal base **56** of the first opening mechanism, then is lowered by the elevator base **55**, so that the lid member **51** for the wall is removed from the aperture **21**, together with the lid member **32**. The transporter arms **81** of the first transporter mechanism **8**A are then inserted into the wafer cassette **3** to pick up and hold five wafers W from the wafer cassette **3** at a time and transport them into the intermediate transfer stand **6**. At the intermediate transfer stand **6**, each of the transporter arms **81** passes through the arm insertion space at the forward side of one of the mounting rings **61**, and mounts the wafers W thereon in such a manner that the tapered surface of the tapered pins **62** of each mounting rings **61** comes into contact with the peripheral edge of a wafer W. Since this causes the peripheral edge of each wafer W to be controlled by the tapered surfaces of the tapered pins **62**, the center of the wafer W is positioned.

After 13 wafers W have been transported in this manner from the wafer cassette **3** to the intermediate transfer stand **6**, the aperture portion **21** for the transfer of wafers is closed by the lid member **51** for the wall. The empty wafer cassette **3** is then replaced by a new wafer cassette **3**, but the positioning of wafers W and the transporting of the wafer boat can be done in the second environment S2 during this replacement.

In other words, the wafers W mounted on the intermediate transfer stand **6** are moved by the transporter arms **81** of the first transporter mechanism **8**A onto the turntables **72** of the positioning mechanism **7** in the second environment S2, as shown in FIG. **5**, and notches in the wafers W are positioned as previously described. Note that upwardly protruding pins (not shown in the figures) project from the upper surface of each turntable **72** of the positioning mechanism **7**, and the wafers W are transferred onto these upwardly pointing pins.

After the wafers W on the positioning mechanism **7** have been transported by the first transporter mechanism **8**A to the intermediate transfer stand **6**, they are transported into the wafer boat WB from the intermediate transfer stand **6** by the transporter arms **81** of the second transporter mechanism **8**B. This wafer boat WB is then inserted into a heat treatment furnace H (see FIG. **1**) that is disposed above the wafer boat WB, for example, and a predetermined heat treatment is performed.

With this wafer transporter apparatus, the aperture **21** is closed by the lid member **51** for the wall when there is no wafer cassette **3** attached to the aperture **21** for the transfer of wafers of the partitioning wall **2**. In addition, the space between the lid member **51** for the wall and the peripheral edge of the aperture **21** is sealed by the sealing member **54**, so that the not-very-clean air of the first environment S1 is prevented from penetrating into the second environment S2.

After the wafer cassette **3** has been attached to the aperture **21**, air from the first environment S1 does penetrate into the gap formed between the wafer cassette **3** in the aperture portion **21** and the lid member **51** for the wall, but this air is replaced with N2 by evacuating this gap while supplying N2 thereto, so that particles brought into this gap by the air are also removed through the exhaust passage **24**.

For that reason, any decrease in the degree of cleanliness within the second environment S2 is suppressed because the first environment S1 is hermetically sealed from the second environment S2 by ensuring that the environment is very clean in the gap while the lid member **51** for the wall is open, and by placing the O-ring **22** between the wafer cassette **3** and the partitioning wall **2**.

Furthermore, since a nitrogen environment is formed within the aperture portion **21** itself in this processing apparatus that creates a nitrogen environment within the second environment S2, there is substantially no danger of oxygen entering the second environment S2 and the second environment S2 can be made to be a predetermined nitrogen environment. Note that another inert gas such as argon, or very clean air, could equally well be used as the pure gas instead of N2.

In addition, since all of the wafers W within the wafer cassette **3** are first moved to a temporary position on the intermediate transfer stand **6** in the above-described wafer transporter apparatus, to create a state in which exchange can be performed while the wafer cassette **3** is empty, the task of exchanging wafer cassettes **3** can be performed in parallel. Therefore, the time taken for positioning the wafers W is not the sum of the time required for transporting the wafers and the time required for exchanging the wafer cassettes **3**; it can be reduced to the time taken to convey the wafers from within the cassette **3** into the processing station. With a hermetically sealed type of wafer cassette **3**, exchanging the wafer cassettes **3** takes a long time and the wafers W must be positioned after they have been fetched out of the wafer cassette **3**, so this is an effective method from the viewpoint of the throughput in the subsequent processing system.

In the embodiment described above, the lid member **51** for the wall and the second opening mechanism **52** could be provided as separate components instead of being integral, and the N2 gas supply passage **23** and the exhaust passage **24** need not necessarily be provided. Furthermore, the resilient material is not limited to the O-ring **22** and a configuration could be used in which the pushing mechanism **45** is not provided. In addition, the configuration could be such that the positioning of the centers and orientations of the wafers W is done by the positioning mechanism **7**, not the intermediate transfer stand **6**, and the intermediate transfer stand **6** could be omitted. The positioning of both the centers and the orientations of the wafers W can be implemented by a combination of the turntables **72** and the mounting rings **61**, for example, where both components are configured to be freely and independently elevatable.

The above-described effects are obtained if the intermediate transfer stand **6** is provided as in this embodiment, but

this can also be applied to a type of system in which air is prevented from penetrating from the first environment **S1** into the second environment **S2** by setting the second environment **S2** to a greater pressure than the first environment **S1** and causing air to flow out of the second environment **S2**, as in the prior art.

A second embodiment of this invention will now be described with reference to FIG. **6**. This embodiment is based on the observation that, when a wafer cassette **3** is pressed towards the step portion **21***a* of the aperture portion **21** for the transfer of wafers and a resilient material such as the O-ring **22** is used as a sealing member therebetween, the amount of crushing of the O-ring **22** is not stable and thus the position at which each wafer cassette **3** is fixed in the attachment/removal direction differs for each wafer cassette **3**.

In other words, the position of the wafer cassette **3** is not constant which means that, even if wafers are accommodated within the wafer cassette **3** with the centers thereof aligned, the pick-up position of the wafers W within the wafer cassette **3** will differ as seen from the transporter arms **81** of the first transporter mechanism **8**A. Therefore, if the stroke of the transporter arms **81** is set to be the same, the center position of the wafers W will deviate at the stage at which they have been transferred onto the transporter arms **81**, making it necessary to re-position the centers. This embodiment is intended to solve this problem.

This embodiment differs from the previously described embodiment in that it is provided with a detection means **9** such as a micro-digital scale for detecting the position at which the cassette mounting portion **4** is fixed, on the forward side (the second environment **S2** side) of the cassette mounting portion **4**. In addition, a detection signal from this detection means **9** is input to a control means C of the first transporter mechanism **8**A, a control signal from this control means C is sent to a drive means **83** of the first transporter mechanism **8**A, and the stroke of the transporter arms **81** is determined on the basis of this control input signal.

This micro-digital scale has a configuration in which a stick **92** protrudes a predetermined distance from a main body **91**, for example, and movement distances of the order of 0.1 mm can be detected by measuring the distance by which this stick **92** is pressed to protrude into the main body. With this embodiment, if the cassette mounting portion **4** stops at an initial position (the position at which the wafer cassette **3** is mounted thereon) that is just a small distance before it touches the O-ring **22**, the tip of this stick **92** is disposed so as to come into contact with the forward surface of the cassette mounting portion **4**. Since the position of the stick **92** is known in this configuration, the position of the cassette mounting portion **4** is also known, the detection signal from the micro-digital scale is transmitted to the control means C as position information of the wafer cassette **3**, and thus the stroke of the transporter arms **81**, that is, their insertion distance into the wafer cassette **3**, can be controlled.

If the amount of crushing of the O-ring **22** is small and thus the movement position of the wafer cassette **3** does not reach a previously determined movement position F, as shown for example in FIG. **7**(*a*), the insertion distance of the transporter arms **81** into the wafer cassette **3** is increased. Conversely, if the amount of crushing of the O-ring **22** is large and thus the movement position of the wafer cassette **3** exceeds the previously determined movement position F, as shown for example in FIG. **7**(*b*), the insertion distance of the transporter arms **81** into the wafer cassette **3** is reduced.

If the insertion distance of the transporter arms **81** is controlled in this manner in accordance with the distance moved by the wafer cassette **3**, and thus the reception position of the wafers W is controlled, the position of the wafers on the transporter arms **81** is always set to be the same even if the degree of crushing of the O-ring **22** differs. Therefore, the position of the centers of the wafers W is fixed, increasing the accuracy with which the wafers W are moved by the transporter arms **81** and making it unnecessary to position the centers anew.

Instead of the micro-digital scale used by way of example as the detection means **9** in the above-described embodiment, other means could be used such as a scaling device, which could be a glass scale, provided on the rails **43** of the cassette mounting portion **4**, for example, in such a manner that the movement position of the cassette mounting portion **4** is detected thereby. This invention can also be applied to an apparatus that uses liquid crystal display substrates, as the substrates to be processed.

In order to reduce contamination by particles of the substrates to be processed as far as possible in the above-described embodiment, a sealed type of cassette is used for the substrates to be processed, the first environment wherein is placed the cassette of substrates to be processed is demarcated from the second environment wherein the substrates to be processed are moved, and the aperture for the attachment of the cassette of substrates to be processed is sealed. Therefore, the purity of the environment in which the substrates to be processed are placed can be kept high and thus contamination of the substrates to be processed can be prevented.

Part of a wafer transporter station that comprises the positioning apparatus of this invention is shown in FIG. **8**. This transporter station is provided with a sealed type of wafer cassette **3**, a wafer transporter mechanism **10**, and a wafer positioning apparatus **11**. The wafer cassette **3** is provided with a casing **31** in which are formed multiple stages of wafer holder grooves **30** in such a manner that a number of wafers W (for example, 13 wafers) are supported vertically at a certain spacing thereby, and a lid member **32** for hermetically sealing an aperture portion that is a wafer transfer port of this casing **31**.

The wafer transporter mechanism **10** is designed to transfer wafers between the wafer cassette **3** and the wafer positioning apparatus **11**, but the wafers could be transferred into means such as a wafer boat if the transporter station is combined with a vertical heat treatment apparatus, or into a load-lock chamber having multiple stages of wafer grooves if it is combined with a vacuum processing apparatus. This wafer transporter mechanism **10** is provided with a plurality of transporter arms **10***a* that are capable of transporting a plurality of wafers at a time. These arms are configured to be freely movable forward/backward, rotatably, and vertically, and the vertical spacing between the transporter arms **10***a* is also variable.

The wafer positioning apparatus **11** is provided with elevator bases Ill which are arrayed in a plurality of stages, such as five stages, and are mounting portions for positioning the centers of wafers. Each of the elevator bases **111** is a plate that is formed to be substantially annular but is cut at a base end side thereof as indicated by reference number **111***a* in the expanded views of FIGS. **9** and **10**. The upper surface of each elevator base **111** is provided with tapered pins **112** that are inclined guide means, at positions around the peripheral edge of the wafer W. A total of ten such pins could be provided, arranged symmetrically, five to a side.

A gap is formed between the tapered pins **112** to the right and left of a tip end portion **111***b* of each elevator base **111** to allow one of the transporter arms **10***a* to be inserted therebetween, and the vertical spacing between adjacent elevator bases **111** is set to correspond to the spacing of the transporter arms **10***a*. The tapered pins **112** are formed of a resin such as Teflon (tradename) and each is shaped as a circular cone with a tip angle θ of 15 degrees, for example, and a height h of 20 mm, as shown in FIG. **11**. The base end side of each of the elevator bases **111** is supported in common by left and right edge portions of an elevator frame **113** of a rectangular shape that extends in the vertical direction.

The positioning apparatus **11** is provided with five turntables **115** as rotational portions that each support the rear surface of a wafer and rotate horizontally. These turntables **115** are each provided on an upper portion of a fixed base **116** corresponding to each of the elevator bases **111**. Each fixed base **116** is disposed slightly lower than the corresponding elevator base **111**, for example, and the base end side of the fixed base **116** passes through a space surrounded by the elevator frame **113** and is fixed in common to a fixed plate **117** that is positioned on a rear surface side of the elevator frame **113**.

Each fixed base **116** is provided with a drive means **119** comprising a drive pulley **118** and a motor M, for example. Each of the turntables **115** is configured so as to be capable of rotating about a vertical rotational shaft that is positioned at the center of a circular region surrounded by the tapered pins **112**, driven by a transmission mechanism such as a belt **120**, for example, strung from the drive pulley **118**. In this example, each turntable **115** is positioned higher than the corresponding elevator base **111**.

The elevator frame **113** is configured in such a manner that it can be raised and lowered by an elevator mechanism **123** (see FIG. **8**) along vertical guides **122** provided on the front surface side of the fixed plate **117**.

Each of the fixed bases **116** is provided with a detector portion, such as an optical sensor **125** having a light-receiving portion and a light-emitting portion, for detecting a notch **100** (see FIG. **12**) or a orientation flat **200** (see FIG. **13**) formed as a cut-out portion for positioning in the circular peripheral edge of a wafer W. This optical sensor **125** is disposed in such a manner that, when a wafer W is mounted on the turntable **115**, a peripheral edge portion of the wafer W is sandwiched between the light-emitting portion and the light-receiving portion in the vertical direction.

A light-receiving output of the optical sensor **125** is input to a control unit **127**. This control unit **127** has the function of controlling the amount of rotation (the angle of rotation) of the turntable by the drive means **119**, in such a manner that the notch **100** (or the orientation flat **200**) of the wafer W is orientated in a predetermined direction, on the basis of the light-receiving output.

The operation of this embodiment will now be described. It is assumed that a sealed cassette **3** has just been mounted on a cassette stage (not shown in the figures) of a wafer transporter station. The space for accommodating wafers within the cassette **3** is ordinarily hermetically shielded from the exterior by the lid member **32**, in a similar manner to that shown in FIG. **2**, but the lid member **32** is opened by the lid opening mechanism (not shown in the figure) for wafer transfer. The transporter arms **10***a* of the wafer transporter mechanism **10** are inserted into the cassette to pick up and hold five wafers W at a time from the cassette **3** and transport them into the wafer positioning apparatus **11**.

The spacing between the transporter arms **10***a* in the vertical direction is 10 mm, for example, when they are taking the wafers from the cassette, but it expands to 30 mm, for example, to correspond to the spacing of the elevator bases **111** when they are transferring them to the wafer positioning apparatus **11**. Each of the transporter arms **10***a* is inserted up to a position that is, for example, 5 mm above the corresponding turntable **115**, as shown in FIG. **14**(*a*). At this point, the elevator base **111** is placed at a level of a height that positions the tapered surfaces of the tapered pins **112** below the peripheral edge of the wafer W, the elevator base **111** is raised by the rising of the elevator frame **113** so that the peripheral edge of the wafer W is supported by the tapered surfaces of the tapered pins **112** as shown in FIG. **14**(*b*), then it is raised even further from this holding position. This lifts the wafer W off the transporter arm **10***a*, then the transporter arm **10***a* withdraws from the positioning apparatus **11**.

The center of the wafer W is positioned by the support thereof by the tapered pins **112**. In other words, the peripheral edge of the wafer W is regulated by the tapered surfaces of the tapered pins **112**, so that if, for example, the center of the wafer W is displaced, the part of the peripheral edge thereof that is on the side to which the center is offset will come into contact with the tapered surface of a tapered pin **112** first, and the rising of that tapered surface will push the peripheral edge back in the horizontal direction. Since locations at the same height on the tapered surfaces of the ten tapered pins **112** are disposed at positions around a circle corresponding to the outer shape of the wafer W, the center position of the wafer is aligned when the wafer W is supported by all of the tapered pins **112** as shown in FIG. **14**(*b*).

The elevator bases **111** are then lowered and the wafers W on the elevator bases **111** are transferred to the turntables **115**, as shown in FIG. **14**(*c*). Each of the turntables **115** is rotated by the drive means **119**. Since the optical axis of the optical sensor **125** is set so that it passes through the cut-out portion of the wafer W, such as the notch **100**, the notch **100** of the wafer W can be detected by the control unit **127** on the basis of the detection signal from the optical sensor **125**, and the turntable **115** is rotated until the orientation of the wafer W reaches a predetermined position.

After the positioning of the center and orientation of each wafer W has been completed, the elevator bases **111** are raised to transfer the wafers W onto the turntables **115**, as shown in FIG. **14**(*d*). The transporter arms **10***a* are then inserted again between the wafers W and the turntables **115**, and the transporter arms **10***a* are raised to transfer the wafers W from the elevator bases **111**, as shown in FIG. **14**(*e*), and transport them into a wafer boat of, for example, a vertical heat treatment apparatus.

In accordance with the above embodiment, throughput is improved because centering and orientation alignment can be performed for a plurality of wafers W at a time, which is effective for coping with the throughput problem when a sealed type of cassette **3** or the like is used. Since the centers of the wafers W are positioned by the tapered pins **112**, then the wafers W are transferred from the tapered pins **112** to the turntables **115** and the orientations thereof are aligned, the configuration is simple. Furthermore, since the mechanism for positioning individual wafers is provided with several stages, a compact dedicated space will suffice therefor.

With the present invention, the configuration could be such that the bases **111** are fixed but the turntables **115** are raised and lowered, and the transporter arms **10***a* are raised

and lowered when the wafers are transferred from the transporter arms **10**a to the bases **111**. However, in such a case, the transporter arms **10**a are positioned above the tapered pins **112** in anticipation of the greatest deviation of the center positions of the wafers, and the wafers W are raised up from below, so that the vertical distance through which the wafers W move will increase and the size of the optical sensor **125** must be increased correspondingly. In contrast, if the bases **111** are raised and lowered, the level of the height of each wafer W is fixed until the wafers W are transferred from the transporter arms **10**a to the bases **111**, so that the vertical distance through which the wafers W move is small and therefore the optical sensor **125** can be made smaller in the vertical direction.

Instead of the tapered pins **112** described above, the inclined guide means could be configured as a protruding portion **112**A extending around the periphery, with the inner peripheral side thereof formed as an inner tapered surface that is inclined in such a manner that it separates from the wafer with increasing height, as shown in FIG. **15**, so that the entire peripheral edge of the wafer (except for locations corresponding to insertion spaces for the transporter arm, etc.) is supported thereby. Furthermore, the positioning mechanism of this invention, comprising components such as the bases **111** and turntables **115**, could equally well be provided as a single stage instead of a number of stages.

A further embodiment of the present invention will now be described with reference to FIGS. **16** and **17**. This embodiment concerns an apparatus for positioning wafer centers while the wafers are accommodated within a wafer cassette. A standard cassette tested under the rules of, for example, the Semiconductor Equipment and Materials Institute (SEMI) is used as the cassette. In these figures, reference number **130** denotes a wafer cassette that is placed in a lateral orientation on a cassette mounting stand **131**, which is a cassette mounting portion, so that wafers W are arranged substantially horizontally. In this lateral orientation of the wafer cassette **130**, an upper surface plate **132** and a lower surface plate **133** are formed to be substantially circular and slightly larger than the outer edge of the wafers W, and front edges **132**a and **133**a of these plates **132** and **133** are formed to a circular arc shape of close to the same radius as that of the outer edge of the wafers W. Side walls **135** and **136** are formed along the peripheral edges of the plates **132** and **133** between the plates **132** and **133** and on the left and right sides thereof, a wall portion **137** is also formed at a rear portion between the plates **132** and **133**, and 13 support grooves **138** are formed on the inner peripheral surfaces of these wall portions **135**, **136**, and **137** to support each of the peripheral edges of 13 wafers.

The space between the arc-shaped front edges **132**a and **133**a of these plates **132** and **133** is formed as an aperture **140** that acts as a port for removing and inserting wafers W. Similarly, portions are cut out of the left and right sides at the rear of the walls **135** and **136** to form apertures **140** between the plates **132** and **133** (see FIG. **17**). The apertures **140** are not really visible in FIG. **17**.

Pushing mechanisms **150**A and **150**B are provided symmetrically on the left and right sides of the cassette **130** for pressing against the peripheral edge portions of the wafers in the cassette **130**. The positioning mechanism of this embodiment of the invention is configured of these pushing mechanisms **150**A and **150**B. The pushing mechanisms **150**A and **150**B have the same construction. Pushing members, such as rotatable rollers **142** rotating about vertical shafts **141** are provided at positions opposite to the peripheral edge portions of the wafers W where they are exposed in the vicinity of the left and right side edges of the aperture **140** of the cassette **130**, that is, at positions opposite to regions facing the front edge surfaces of the walls **135** and **136**.

Each of the rollers **142** is divided into sections for each wafer W, corresponding to the wafers W within the cassette, so that the same number of roller elements **142**a as the number of wafers W in the cassette, such as 13, are arrayed in the heightwise direction to correspond to the heightwise positions of the wafers W. Spacer members that cannot be seen in the figures are threaded onto each shaft **141** between the roller members **142**a, to maintain the spacing between the roller members, so that the roller members **142**a can rotate independently without rubbing against each other.

Rollers **145** that are similar to the rollers **142** and are free to rotate about vertical shafts **144** are also provided at positions opposite to the apertures **141** formed to the left and right of the rear side of the cassette **130**. Lower end portions of the shafts **141** and **144** of these rollers **142** and **145** are fixed to common sliding plates **148**. The upper ends of these shafts **141** and **144** are connected together by linking members **147**.

The sliding plates **148** are configured to be free to move forwards and backwards in a direction perpendicular to a center line L linking the front and rear of the cassette **130** (so that they move to the left and right in FIG. **16**), while being guided along guide rails **150** and **151**. A drive portion such as an air cylinder **152** is provided on a side portion of each sliding plate **148** for moving that sliding plate **148** forwards and backwards. The four rollers **142** and **145** of the pressuring mechanisms **150**A and **150**B are positioned in such a manner that they are in contact with the peripheral edges of the wafers W when the centers of the wafers W in the cassette **130** are aligned. A material such as Teflon (tradename) is used for the rollers **142** and **145**.

With the above-described embodiment, a cassette **130** containing 13 wafers W, for example, is placed laterally on the cassette mounting stand **131** of a cassette entrance/exit port of a vertical heat treatment apparatus or the like. At this point, the rollers **142** and **145** of the transporter mechanism are moved back to positions where they do not impede the cassette **130**. After the cassette **130** has been placed on the mounting stand **131**, the sliding plates **148** are moved forwards by the air cylinders **152** to press the rollers towards the direction of the centerline L at four locations on the peripheral edge portions of the wafers exposed from the apertures **140** and **141** of the cassette **130**, whereby the centers of all of the wafers W within the cassette **130** are simultaneously positioned. The rollers **142** and **145** then move back and conveyor arms (not shown in the figures) start removing the wafers W within the cassette **130**.

This pair of pushing mechanisms **150**A and **150**B are disposed facing towards the left and right in FIG. **17**, but the same positioning effect could be obtained by a pair of pushing mechanisms **150**C and **150**D disposed at the top and bottom of the paper in FIG. **17**.

In the embodiment described above, the center positioning can be performed for all of the wafers W within the cassette **130**, thus making it possible to improve the throughput. This embodiment is effective because the previously mentioned standard cassette is fabricated to dimensions with tolerances concerning wafer size and thus the permissible positioning accuracy of the centers of the wafers is only the order of within a circular region of diameter 4 mm. For processing in which the orientation of the wafers is not too critical, the wafers within the cassette can be transferred as they are into the processing station. Alternatively, if accurate

alignment of the wafer orientation is required, alignment of the wafer orientation alone can be performed subsequently, so that a simple mechanism will suffice for the positioning.

Note that the members that press against the peripheral edges of the wafers are not limited to rollers, but the use of rollers makes it possible to suppress the generation of particles due to friction because the rollers rotate when tangential forces are applied thereto during the pushing. In addition, a single roller could be used in common for all of the wafers, but the use of rollers that are separated for each of the wafers means that they can rotate independently in answer to any deviation in the central position of individual wafers, enabling a further suppression of friction between the rollers and the wafer edges.

It should be noted that the type of cassette is not limited to the standard cassette shown in FIG. 7. Similarly, the pressuring of the wafer edges could be done at three or more locations; it is not limited to four locations.

The above description concerned the positioning of wafers accommodated within a cassette, but the principles described herein can also be used for centering a wafer that is mounted on a notch aligner device.

Since the present invention combines a rotational mounting portion with a mounting portion that is provided with a tapered portion and is used to center a wafer, it enables positioning of the center and orientation of a wafer by a simple configuration. It is also possible to position a plurality of wafers a time, by providing a plurality of stages of the positioning mechanism formed of these mounting portions. Since the apparatus is configured in such a manner that the peripheral edges of wafers exposed from a wafer cassette are pushed in at least three locations, centering can be performed on wafers within the wafer cassette.

What is claimed is:

1. An apparatus for positioning substrates to be processed, comprising:

a substrate cassette for horizontally supporting therein a plurality of substrates at intervals in a vertical direction without regard for whether the center of each substrate is aligned with the center of any other substrate, said substrate cassette having side walls defining a plurality of side apertures in a shape which allows outer peripheral edges of the substrates supported in said cassette to be exposed outside the cassette; and

pushing mechanisms disposed outside said substrate cassette and provided to move toward and away from said side apertures, each of said pushing mechanisms having a pair of vertically and parallelly extending rotatable rollers having a vertical length engageable with the exposed outer peripheral edges of all of the substrates in the cassette to press and position the substrates whereby the center of each substrate comes into alignment with the center of each other substrate in said cassette to define a common vertical axis through the substrates when the pushing mechanism moves to one of said apertures,

wherein said pushing mechanisms are provided on opposite sides of the substrate cassette, respectively, to move toward and away from each other.

2. The apparatus as defined in claim 1, wherein said substrate cassette has an upper surface plate and a lower surface plate.

3. The apparatus as defined in claim 1, wherein each of said rotatable rollers is formed of a plurality of independently rotatable roller elements.

4. The apparatus as defined in claim 1, wherein each of said pushing mechanisms is movable on and along guide rails.

5. The apparatus as defined in claim 1, wherein said rotatable rollers are supported on a common plate movable on and along guide rails, said rotatable rollers being connected to each other at upper ends thereof through a linking member.

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